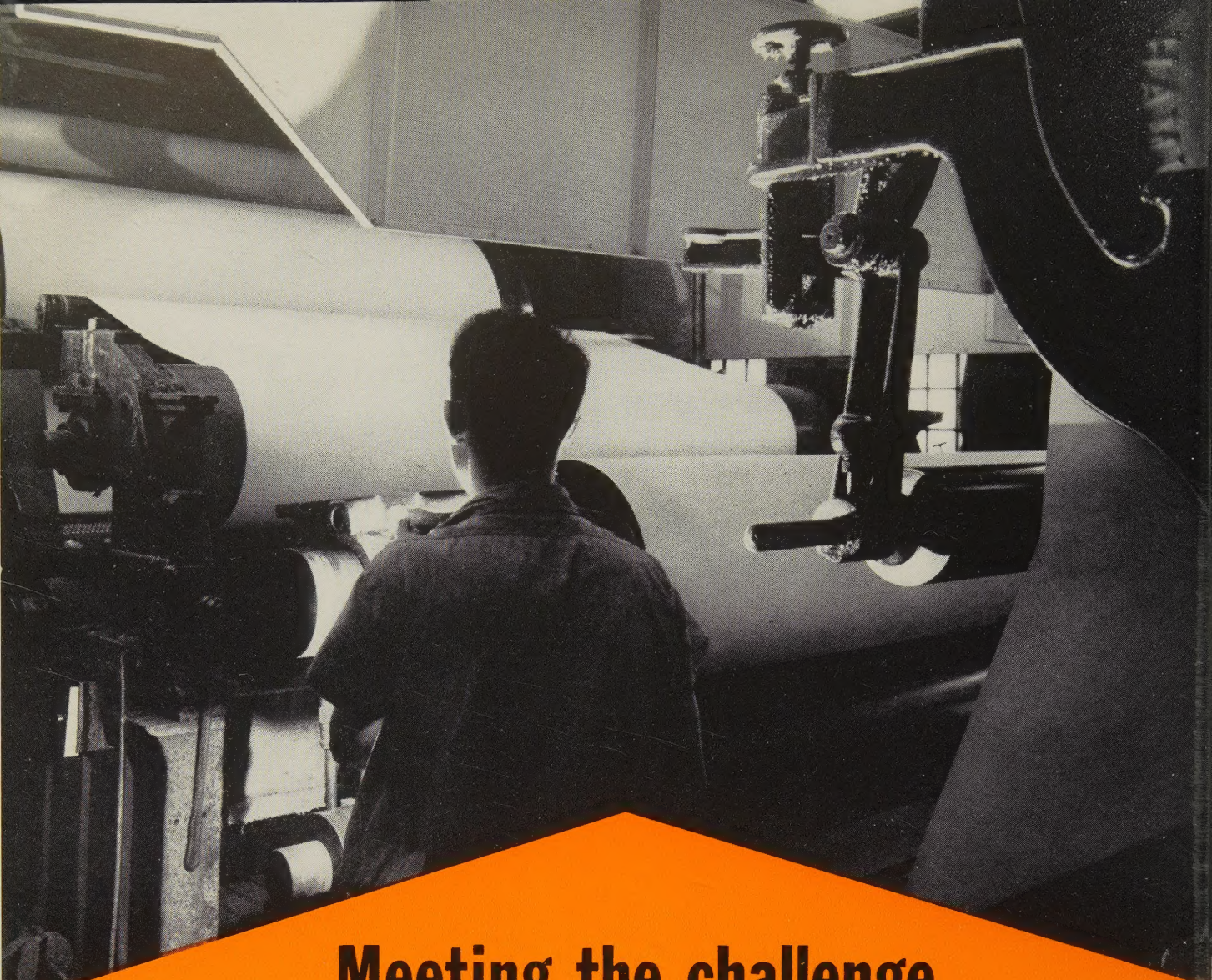
Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JUNE 1955

VOLUME 38 • NUMBER 6



Meeting the challenge

of today's modern processes...the versatile, efficient

CALCOTONE* PIGMENT PASTES

New processes, new additives, new and more exacting specifications for paper—these, separately and collectively, present a challenge to color performance. *This challenge is met in all respects by the Calcotone Pigment Pastes, developed especially to give top performance in today's modern processes.* Consider these qualities:

...fine particle size that insures rapid and complete dispersion in the beater or coating mixture to give full color value

...compatibility with most additives

...good lightfastness, chemical stability and bleed resistance.

These properties are the reasons why Calcotone Pigment Pastes are now widely used on all grades of specialty papers from tissue to heavy-weight board. You will do well to include Calcotones as regular items in your color room.

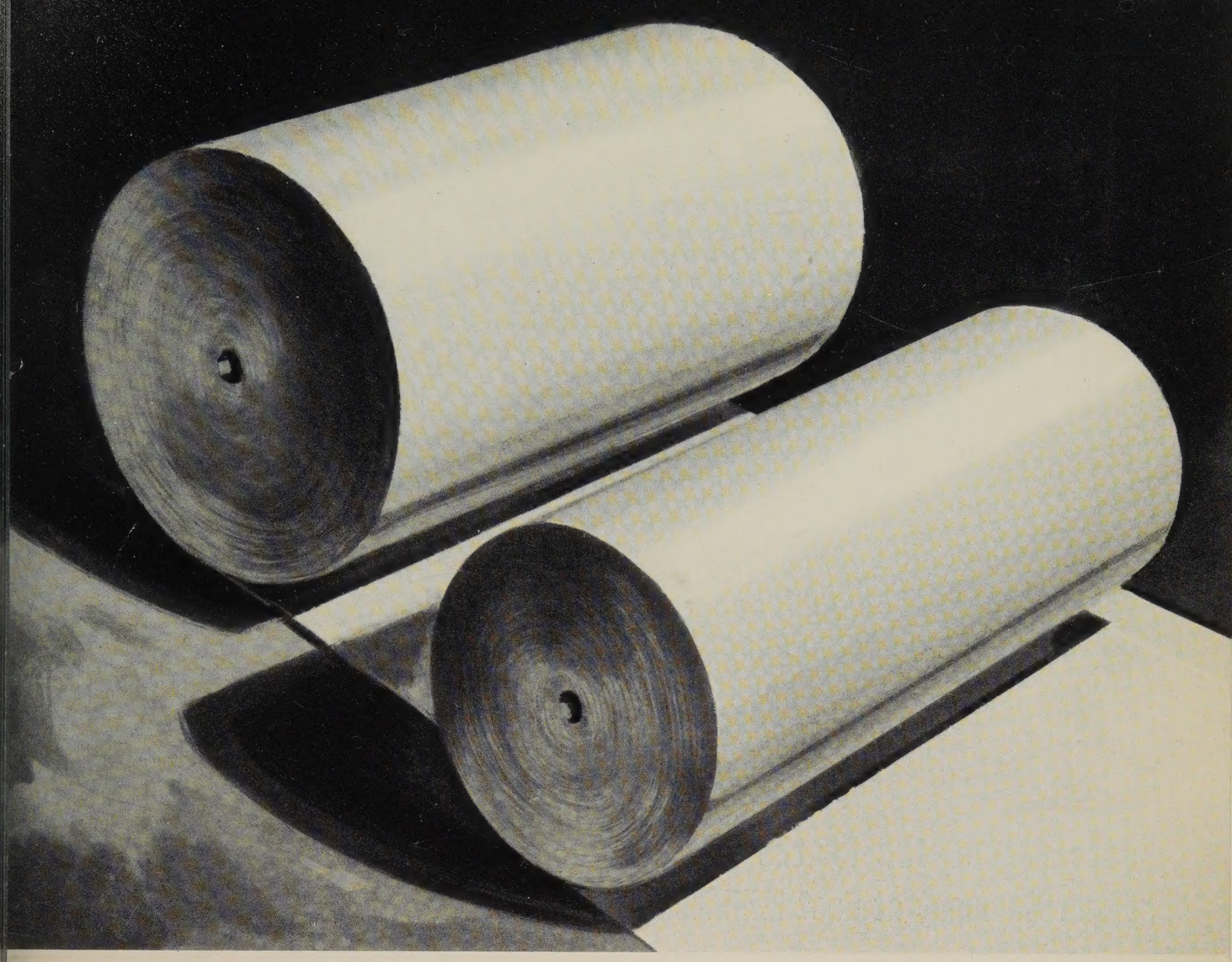
Why not take this matter up with your Cyanamid Dyestuff representative on his next visit to your plant?

*Trade-mark

Calco®

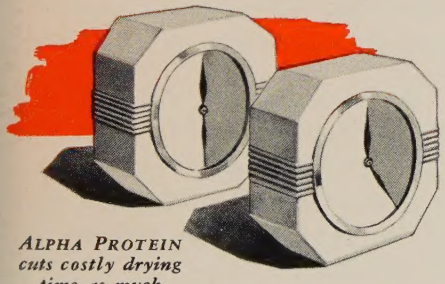
AMERICAN Cyanamid COMPANY
DYESTUFF DEPARTMENT
BOUND BROOK, NEW JERSEY
NEW YORK • CHICAGO • BOSTON • PHILADELPHIA • CHARLOTTE
PROVIDENCE • ATLANTA • LOS ANGELES • PORTLAND, OREGON

NORTH AMERICAN CYANAMID LIMITED
DYESTUFF DEPARTMENT
MONTREAL AND TORONTO



Production increased up to 15% with Alpha Protein®

...THE HIGH SOLIDS COATING ADHESIVE FOR OFFSET PAPERS



ALPHA PROTEIN cuts costly drying time as much as 15%.

Solids in coatings increased up to 12% by ALPHA PROTEIN

It's the extra solids in an Alpha Protein formulated adhesive which make possible production increases as much as 15%. More solids mean fastest drying, highest machine speeds. In addition, Alpha Protein improves printability, increases water resistance, gives greater uniformity and assures sharper reproduction. If you wish, the Glidden specialists in paper manufacturing will pilot test Alpha Protein to your requirements. This way they can make recommendations from laboratory and field experience long before you tie up any of your costly production equipment. Call Glidden for fast, competent service on all of your high solids coating needs.

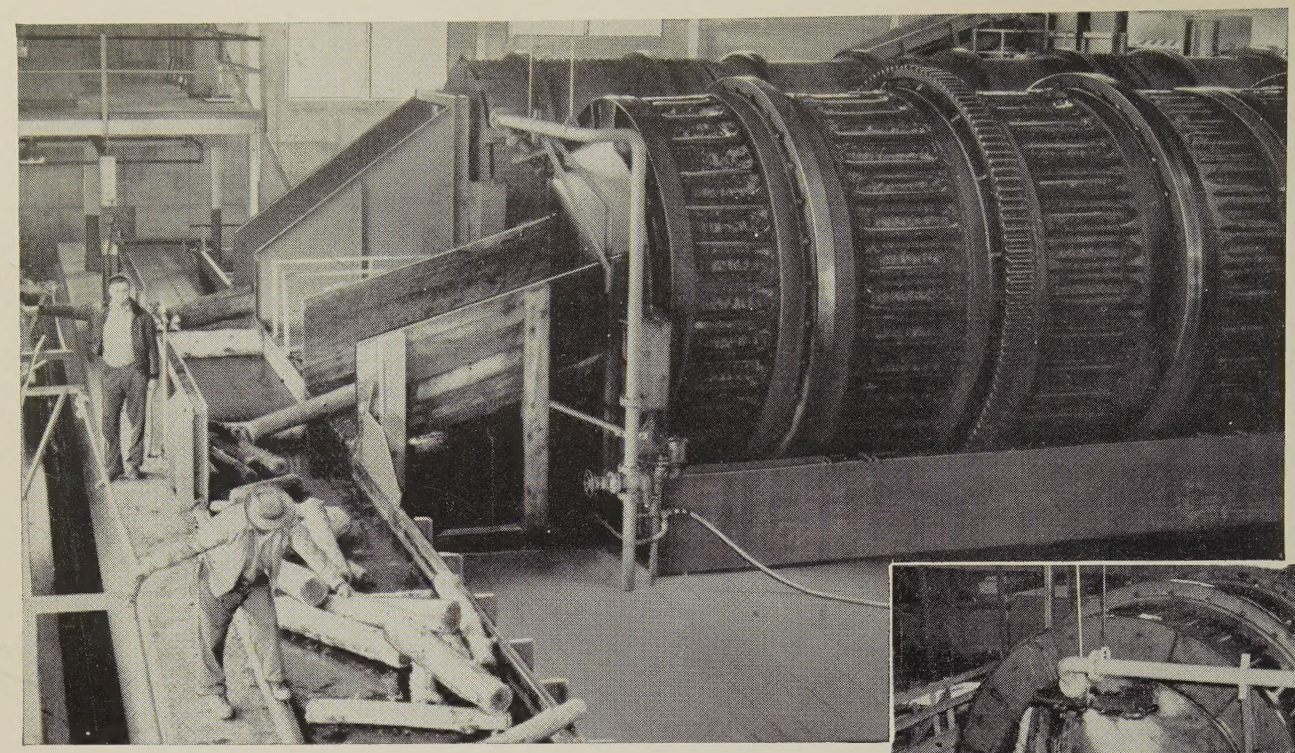
This advertisement is printed on paper processed with Glidden Alpha Protein. It is typical of the superior reproduction that can be obtained.

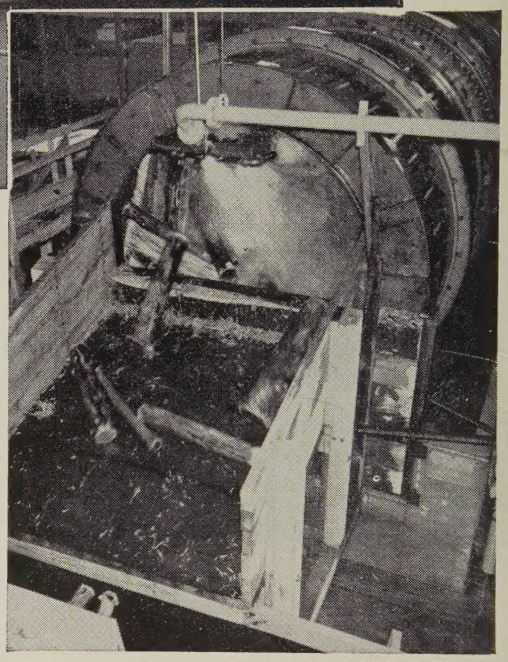
THE GLIDDEN COMPANY

Chemurgy Division

1825 N. Laramie Street • Chicago 39, Illinois

QUALITY Glidden PRODUCTS





WELDRUM BARKER

does a GOOD JOB for the Great Northern Paper Company at East Millinocket, Maine

HERE'S WHY:

BARKS UP TO 30% MORE WOOD because:

1 • *12% to 14% greater cubic capacity*

2 • *Rugged Construction for heavy loading.*

3 • *Ample bark escape slots — discharged wood is clean.*

SHELL MAINTENANCE NO LONGER A PROBLEM because:

1 • *Exclusive welded fastening.**

2 • *Better distribution of shock loads.*

3 • *High section modulus eliminates distortion.*

GET THE WHOLE STORY BY WRITING

Canadian Ingersoll-Rand Company Limited

620 CATHCART STREET, MONTREAL, QUEBEC

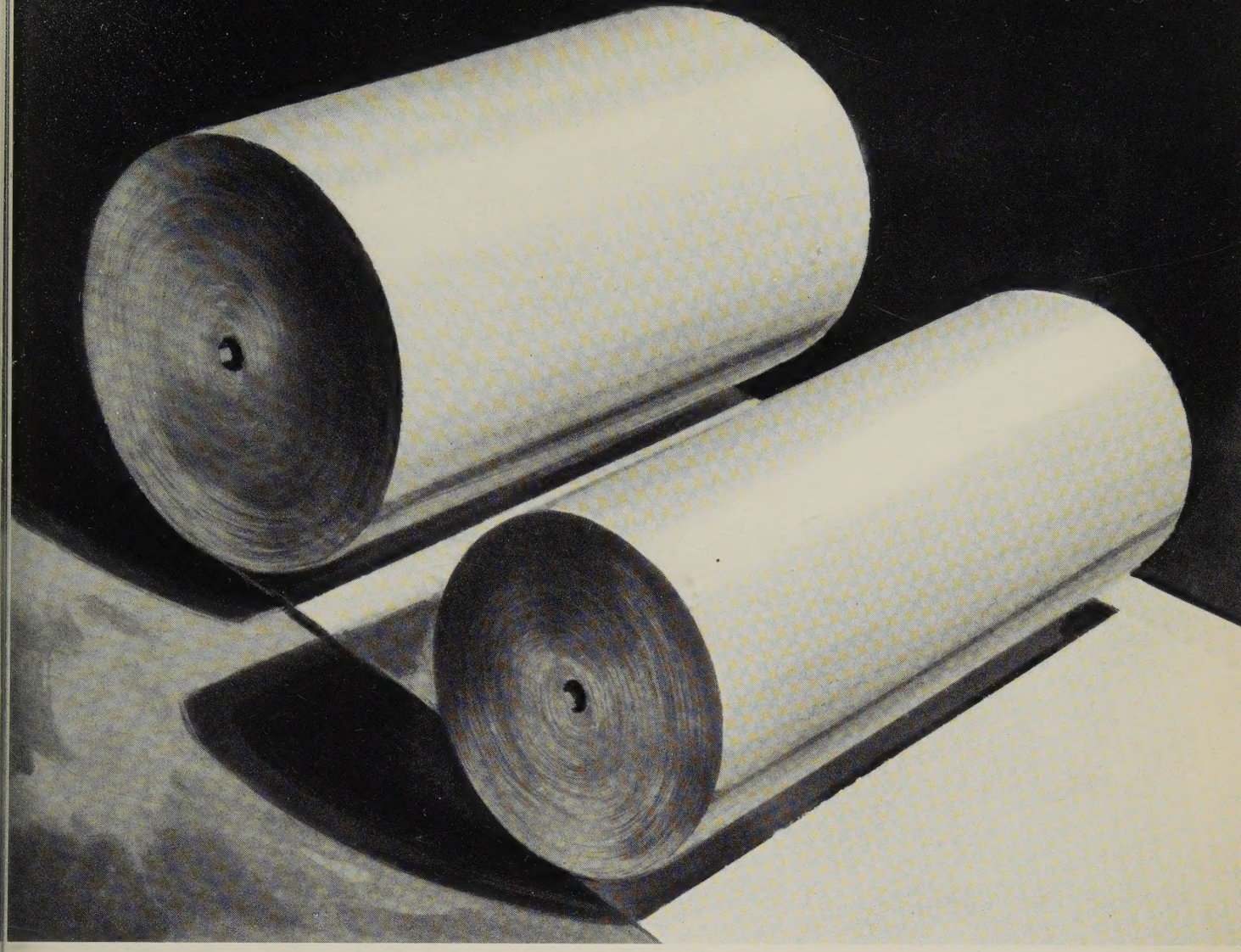
BRANCHES: ST. JOHN'S • SYDNEY • SHERBROOKE • MONTREAL • TORONTO
KIRKLAND LAKE • TIMMINS • WINNIPEG • CALGARY • NELSON • VANCOUVER

On spruce and fir the "Weldrum" at Great Northern barks as much as 50 cords per hour. Production is expected to be proportionately high on hardwood.

The "Weldrum Barker" has enjoyed wide acceptance in Canada because of its superior strength and barking ability. This performance can be duplicated for all the barking conditions existing in mills in the U.S.A.

BETTER PULP AND PAPER • MORE PER DAY • AT LESS COST • PER TON • IR CANADA

* *WRITE FOR* bulletin No. C2105.10 and reprint, "Modern Developments in Barking Drum Design".



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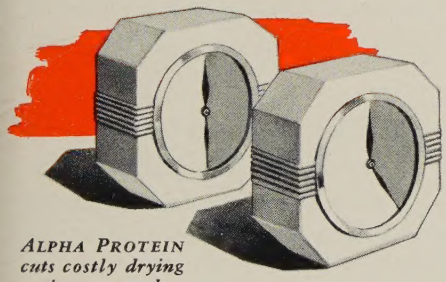

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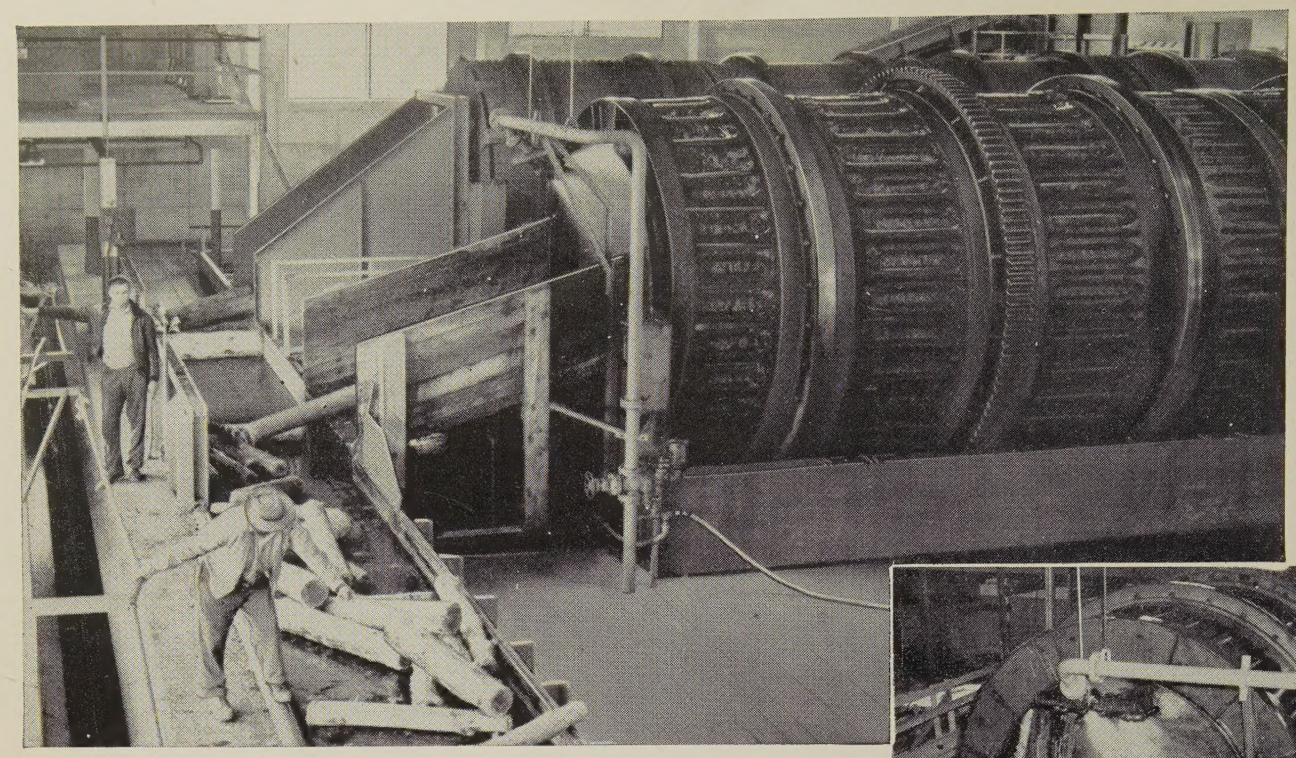

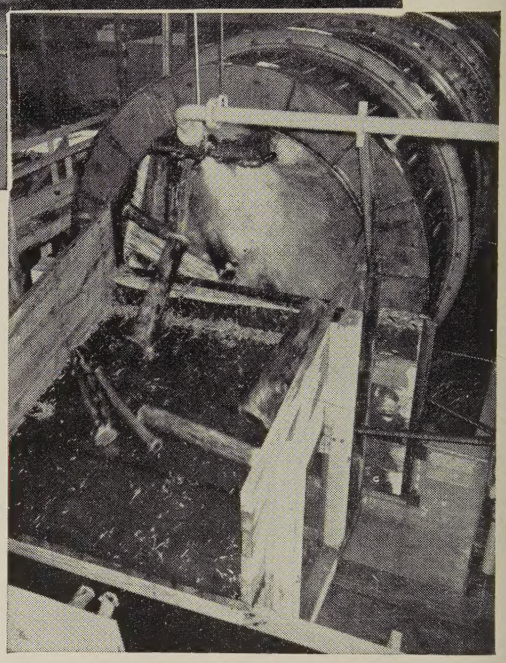

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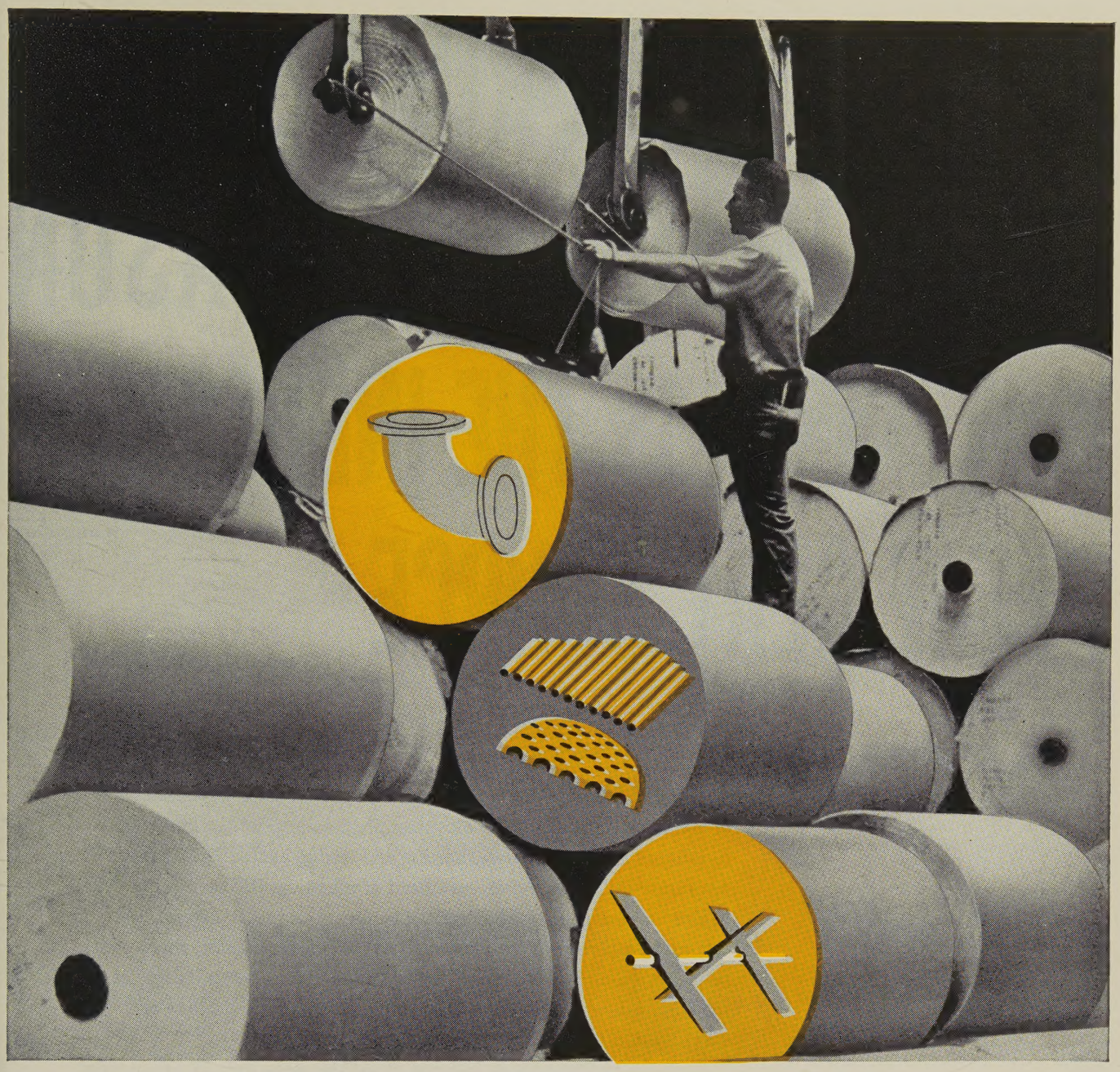

how STAINLESS *steel helps make better paper at lower cost...*

Slime control . . . continuous cleanliness . . . and low machine upkeep — these are the important functions of stainless in the paper mill.

Many vital parts of paper making machines *depend* upon the durability and freedom from corrosion that stainless steel delivers. For example, valves and fittings, stock lines, screens, regulator mechanisms, save-all trays, flow and head boxes are all profitably made of stainless steel.

And while long-range economy *suggests* stainless in any mill, the strict quality requirement of some types of paper making *demands* stainless equipment. For stainless eliminates the problem of contamination and discolored paper due to iron pickup.

Crucible will be glad to help you cut costs with stainless. For practical information on ways of doing it, write for your free copy of the 20-page booklet "Making the Most of Stainless Steels in the Pulp and Paper Industry." *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

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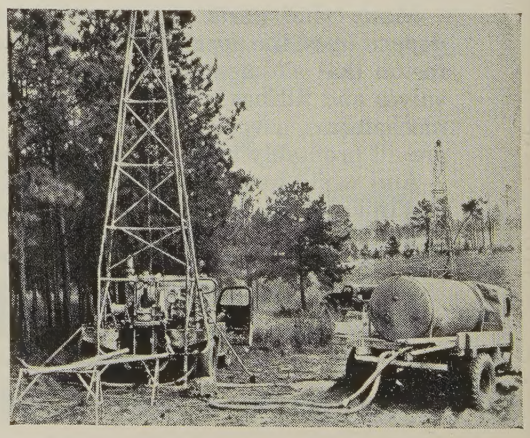
SCIENTIFIC PROSPECTING IS ONE IMPORTANT REASON WHY HUBER IS THE INDUSTRY'S PRIME CLAY SOURCE

PROSPECTING by Huber engineers goes years in advance of actual clay removal. The most complete and up-to-date materials and techniques for core drilling, charting and testing enable Huber to map out future mining activities far ahead of schedule. Before mining ever begins at a particular location, Huber prospecting has determined essential properties of the clay, such as particle size, color, rheological behavior. Accurate maps show depths of overburden and slope of the clay bed; and laboratory evaluation shows the suitability of every section of the bed for specific end uses.

Scientific prospecting is *just one* of all the steps toward production of Huber clays which guarantee you consistent quality, controlled-viscosity clay (as Hydrous clays sometimes require) every time you order from Huber; and a plentiful, uninterrupted supply, year after year.

Only Huber offers you a total combined range of products, methods and services without duplicate in the industry. Only Huber offers you a total range of production methods: spray, drum, rotary, tunnel dried; *plus* a total range of clays: airfloated, waterwashed, filler, coating; *plus* vast storage facilities and selective mining; *plus* unique quality controls such as the patented pugmill process that gives you VISCONTROL—patented viscosity control. No other clay producer in America matches Huber as the industry's prime source of supply... *Be sure of your order—order Huber.*



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JUNE 1955

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TECHNICAL ARTICLES

Insect Resistant Packaging, the Background of the Problem, *by Willis M. Van Horn* 321
The Status of Federal Research on the Development of Insect-Resistant Packages, *by Hamilton Laudani and Dean F. Davis* 322
Insect Repellent Coatings for Multiwall Paper Bags, *by K. A. Arnold* 326
Premix Food Packages and Some Chemical Treatments to Reduce Penetration by Insects, *by H. E. Gray* 329
The Development of an Insect Resistant Folding Carton, *by Richard I. Rice* 333
A Laboratory Method of Evaluating the Repellency of Treated Paper to Stored-Product Insects *by Hamilton Laudani, Dean F. Davis and George R. Swank* 336
Some Factors Affecting the Laboratory Testing of Packages for Resistance to Boring Insects, *by David G. Edwards* 341
The Identification of Digester Corrosion Conditions and Methods for Their Prevention, *by Louis A. Dela Grange* 347
The Development of the Idar Stock Refining Process, *by E. H. Cumpston, Jr.* 353
Noise Problems in Pulp and Paper Mills, *by M. N. Davis and R. H. Caston* 359
The Sulzer System of Water Extraction for Paper Machines, *by Robert Thomann* 365
Five Year Investigation of Digester Corrosion by the TAPPI Chemical Engineering Subcommittee, *by J. R. Lientz, S. J. Baisch, H. O. Teeple, and N. Shoumatoff* 373
Correlation Between Chlorine Number and Lignin Content of High-Yield Kraft Pulps, *by E. L. Keller and Peter B. Borlew* 379
Measurement of Retention of Resins in Paper, *by R. Bhargava, H. A. Hoffman and V. Stannett* 383

DEPARTMENTS

Industry and the Community, by *G. W. E. Nicholson* ..... 14 A
World Pulp and Paper Resources and Prospects —I ..... 22 A
Association News and Events ..... 89 A
Personal Mention ..... 92 A
Divisions and Committees ..... 118 A
TAPPI Fibrary ..... 121 A
Recent Books ..... 127 A
Letters to the Editor ..... 128 A
Employment Service ..... 129 A
Local Section Activities ..... 131 A
What the Printer Would Like to Have from the Papermaker, by *P. E. Tobias* ..... 134 A
Paper—As Concerns Printability and Ink, by *P. H. Hershey* ..... 135 A
Two-Slice Headboxes for Fourdrinier Machines, *by W. B. Roberson* ..... 142 A
Shibley Award Papers—1955
A Rapid Method for the Determination of Alpha-Cellulose in Pulp, *by K. A. E. Blackmore* ..... 146 A
Paper Handling at the Trimmers, *by J. V. Gould* ..... 149 A
A Simple Test to Aid in the Control of Brown Stock Washing, *by J. B. Griffith* ..... 151 A
Unique Structural Treatment in New Filter Plant, *by D. K. Wooden* ..... 156 A
Neutral Sulphite Semichemical Recovery Systems, *by Roderick O'Donoghue* ..... 162 A
Technical Manpower and Technical Information, *by T. T. Collins, Jr.* ..... 167 A
Turbidity Number—A Measure of Pulp Additive Retention, *by J. S. Hickman* ..... 170 A
The Use of Reactive Titania for Crosslinking Cellulose Fibers and for Fixation of Inorganic Fillers to Cellulose, *by Paul Lagally* ..... 172 A
Calendar of TAPPI Meetings ..... 176 A

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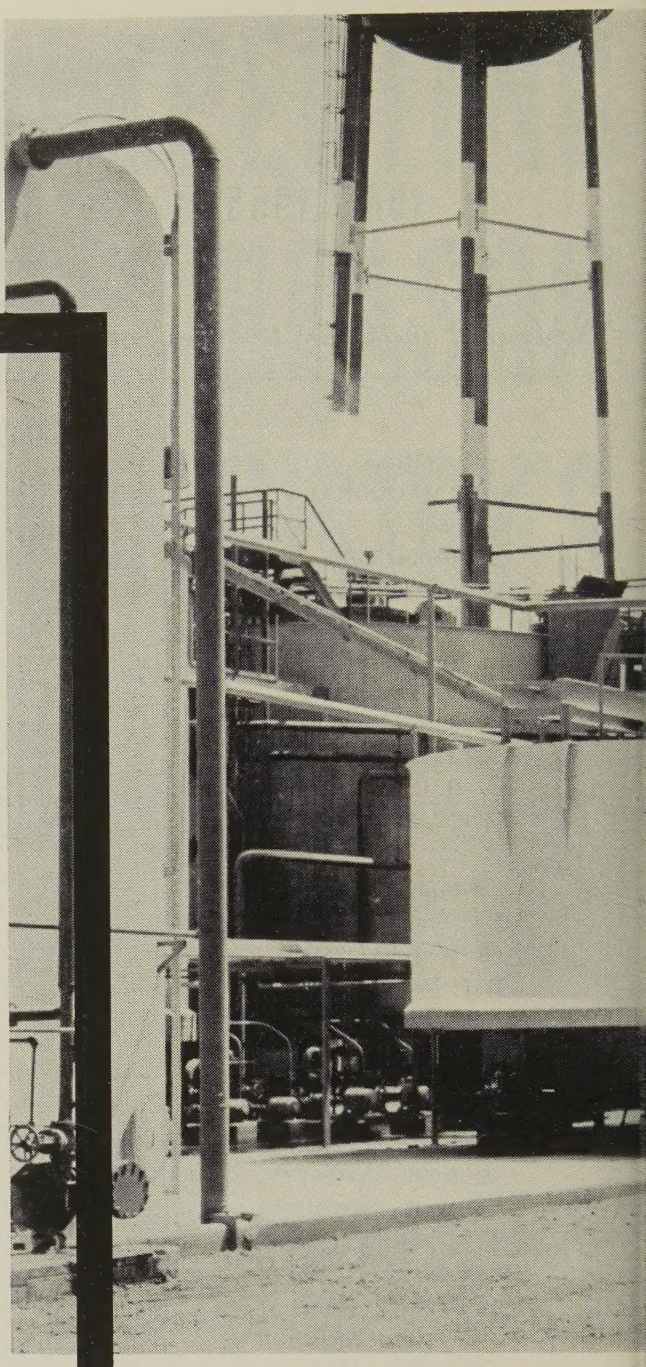
New Development

in Dorr Continuous Recausticizing System

Substantially Reduces Initial Costs...

Simplifies Operation



Latest development in Dorr Continuous Recausticizing is embodied in the Green Liquor Clarifier and Dregs Washer shown in the photograph above. Installed at the Valdosta, Georgia mill of National Container Corporation, the units incorporate a new principle which makes possible a saving of up to 50% in mechanism and tank costs. Instead of multiple compartments served by separate mechanisms, each unit now consists of a single compartment with one mechanism and incorporating a large diameter deep feedwell extending well down toward the bottom of the tank.

The ratio of depth to tank diameter is adjusted to bring into balance the various functions essential to good clarification. Hydraulically, the flow patterns produced are controlled to make maximum utilization of overall tank volume.

This recently proven principal of Selective Density Feeding as applied to the Dorr System means substantially lower investment costs, lower maintenance costs, and simplified operation. In existing Systems the green liquor station can be converted to this new unit design and in most cases will give equal performance to that of tray units with the added advantage of greatly simplified operation.

The remainder of the Dorr System at Valdosta is standard in all respects and includes two Oliver Lime Mud Filters, both 6′ diameter by 6′ face.

If you'd like more information on these new developments in the Dorr Continuous Recausticizing System, write Dorr-Oliver Incorporated, Stamford, Conn. In Canada, 26 St. Clair Ave. E., Toronto 5.

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WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
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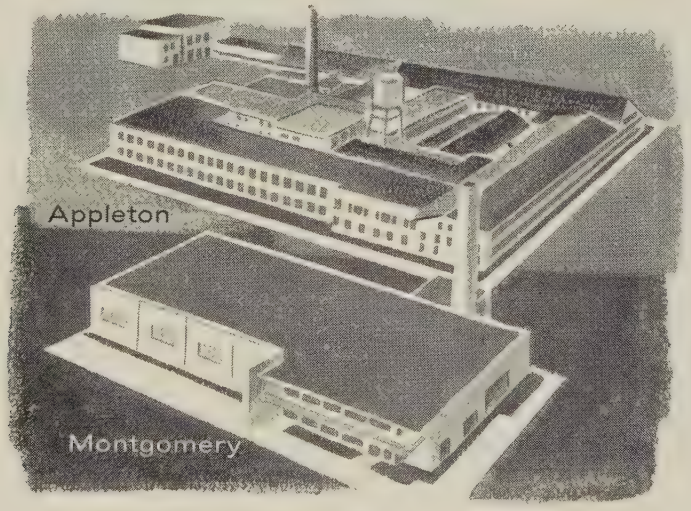
Paper helps Mother all through the house



General Offices, Appleton, Wisconsin

Plants at Appleton, and Montgomery, Alabama.

Happy the home where household papers do their countless and important chores. A tidier home, brighter and healthier too. From tissues for winter noses to gay colors for cupboard shelves—napkins to towels, food wraps to polishing cloths—Mother is really papering the house these days. Efficiently, economically, attractively.

And in at the start of household papers—in every field where paper goes to work... Fourdrinier wires. Appleton Wires. Good wires—by a 59-year test of industry-wide acceptance and use.

Appleton Wire Works, Inc.

ADDED PROFITS

come with CHEMIGUM LATEX

CHEMIGUM LATEX is an aqueous dispersion of a butadiene-acrylonitrile copolymer. When added to Kraft or other pulps in the beater, it can bring you premium profits through the premium properties imparted to the finished sheet.

Here are the major improvements brought about by the beater-addition of 5 to 20 parts CHEMIGUM LATEX on the dry pulp: Much higher edge tear. Soft feel. Cloth-like, rubbery stretch. Improved drape. Added burst strength. Better bending and folding. Greater oil- and grease-resistance. And each can be varied to meet specific needs by the amount of latex added.

The addition of CHEMIGUM LATEX is a simple, straightforward process. It is added as received – no sensitizing or special equipment needed. The sheet is formed in the usual manner. The result is a number of reasons for added profits to both maker and converter. For details on this and other uses – coatings, inks and adhesives–for CHEMIGUM LATEX, write to:

Goodyear, Chemical Division, Akron 16, Ohio

CHEMICAL GOODYEAR DIVISION

Chemigum, Pliobond, Plioflex, Pliolite, Plio-Tuf, Pliovic –T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

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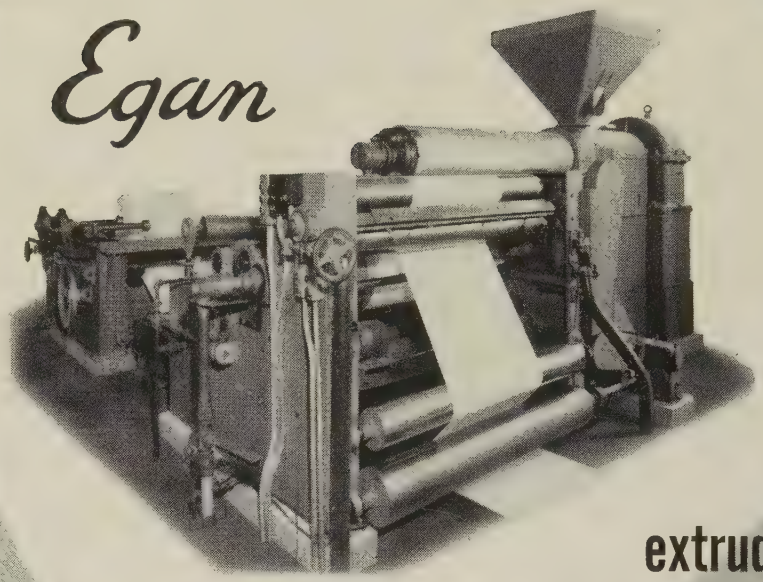

polyethylene extruder-laminator

(Above pictured installation at the Milford, N. J. plant of RIEGEL PAPER CORPORATION)

COMPLETE PACKAGED MACHINE

Combining in one unit, in engineered balance, two famous units—The Egan Extruder and the Egan Laminator. Planned for your current—or expanding—production, available in varying sizes—from 24" Pilot Plant Size to 96", 1000 feet per minute continuous operation. Machines are capable of coating on paper and paperboard, cellophane, foil, glassine and cloth.

35
30 **Egan machines now in operation.**
5 9 **Egan machines under construction.**

Approximately 75% of all polyethylene laminating machines now in operation anywhere in the world are Egan Equipment.

FRANK W. EGAN & COMPANY, Somerville, New Jersey

Designers and Builders of Machinery for the Paper Converting and Plastics Industries

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The Most Versatile Wax Sizes Used in the Paper Mill

The NOPCO® 1055 and 1155 Series

Whatever your main objectives in any paper or board you make, the Nopco technical staff is confident they can help you attain them—quite possibly at lower production costs—with one of the several sizes in these two new series.

Realizing that paper makers have advanced in recent years into many new and diversified applications, the Nopco technical men are keeping pace with your needs, at times are even ahead of them.

We have space here to show only a very few of the many applications (more than 150) in which the Nopco 1055 (all wax) and the Nopco 1155 (rosin-wax) Sizes are today serving paper makers well.

We invite you to *be sure* you have the most economical, most effective wax sizes for each of your specialized jobs, by testing in your own plant these sizes "against the field." Write—today—for the recommendations and skilled counsel of the Nopco paper technicians.

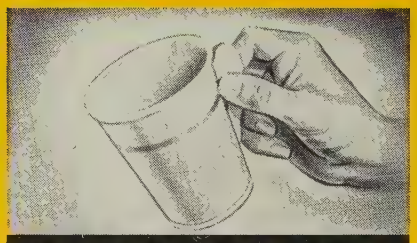
Nopco Chemical Company,
430 Water St., Harrison, N. J.

NOPCO

PLANTS: Harrison, N. J.
Cedartown, Ga. • Richmond, Calif.
London, Ont. Canada

A Few of the Things These Sizes Do Better

High grease resistance. The board used in containers for greasy materials is greatly improved by using one of the Nopco 1055 all-wax sizes in conjunction with silicate of soda or other grease resistant materials.



Greater resistance to hot liquids —lactic acid, too. Whether you apply your size internally or on the surface, we recommend Nopco 1055-B or M, or 1115-B. 1055-B has a wax melting point of 133° —135° F; 1055-M melts at 170°—175° F.

Improved scuff resistance, printability, fold. For test liner stock, several of the Nopco wax (1055 Series) and rosin-wax (1155 Series) sizes offer many advantages. Often the need for internal sizing is eliminated, thus lowering production costs and permitting the board to be sized at a neutral or alkaline pH.

"VIRGINIA" ZINC HYDRO

cuts groundwood bleaching costs 50%
increases brightness 12 points

That's the kind of brightening job "Virginia" can do on your groundwood pulp. That's the kind of savings which use of our reducing agent puts in your pocket.

Some mills have gained as much as 13 points, at one-third the cost of oxidizing bleaches. Saving: a cool $8 per ton. Bleaching with our zinc hydro can be done for as little as 60c per brightness-point per ton. And brightening is *permanent*—there is no reversion of color.

Low-cost "Virginia" Zinc Hydro is non-corrosive, stable in storage, easy to use in the plant. No expensive special equipment is needed. Many auxiliary chemicals are eliminated. "Virginia" Zinc Hydro works just as well in a small, non-integrated mill as it does in a large, continuous-production groundwood operation.

Call on us for proof of all this. The technical and practical knowhow of our experts is at your disposal. Write us today.

Industrial Department
VIRGINIA SMELTING COMPANY
Dept. 77-P, West Norfolk, Virginia

VIRGINIA Chemicals

Field Offices: NEW YORK • BOSTON • DETROIT
CHICAGO • ATLANTA • ASHEVILLE
Available in Canada and many other countries

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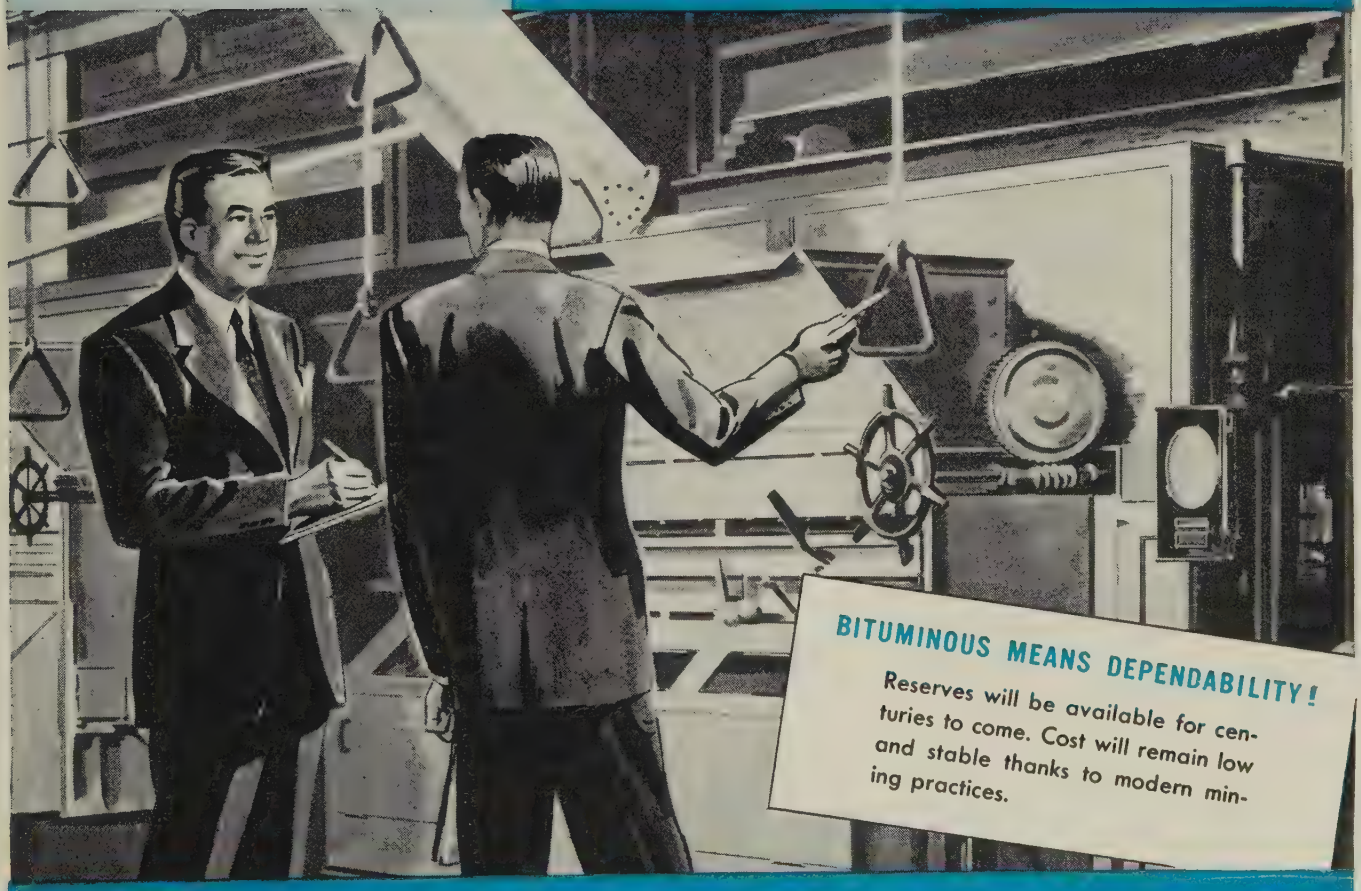

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Industry and the Community

G. W. E. NICHOLSON

G. W. E. Nicholson

WHEN your president asked me some time ago to speak to the Exchange Club about industry and the community, he reminded me of the time that I was a resident of Savannah and of my participation in the affairs of the community.

Union Bag & Paper Corporation's plant had been in operation for about $3^1/_2$ years when I assumed the resident managership during the summer of 1941. I lived here for about 5 years, then I was transferred to New York and placed in charge of all of the company's manufacturing. My present duties make it necessary for me to spend some time in Savannah, in Trenton, N. J. and Chicago, Ill., where we have box plants, and in St. Louis, Mo., where we recently opened a multiwall bag plant.

We operate, as you probably know, the largest plant of its kind in the world in Savannah, and practically every month since the plant was opened in 1936, we have been in the midst of an expansion program. Because of this, my visits to Savannah occur quite frequently, and this does not displease me at all because I have always enjoyed returning to Savannah. This affords me the chance of renewing the number of friendships I was fortunate to make while living here.

Besides being the world's largest pulp and paper mill and integrated kraft operation, I can say to you, and I hope with justifiable pride, that the personnel of the Savannah plant represents one of the most outstanding and capable operating organizations in the entire American pulp and paper industry.

Your president, Mr. Morrison, has played and is playing a most important part in our management. If time would permit, I could tell you a great deal about his personal career and development in our organization since I first met him 14 years ago. I could in many ways use him as my subject or as an illustration of how many of the key men in our organization have gone through the various steps from the ranks into more important positions in the management group.

In talking to you about industry and the community, it would be a little difficult for me to explore the subject if I did not say something about our own industrial organization and its place in the Savannah community and the State of Georgia since we began operations here about 18 years ago.

Starting up of the first pulp and paper mill unit together with a bag converting operation meant that skilled and experienced personnel from other plants owned by Union Bag & Paper Corp. were transferred to Savannah. They came from such places as Chicago, Ill.; Hudson Falls, N. Y.; and Bogalusa, La. Most of these were integrated in our bag plant operation. At the same time, experienced technical men and skilled workers were also brought in from various southern pulp and paper mills for the operation of the pulp and paper mill and these represented a nucleus of our organization.

The great majority of the total working force, however, was represented by men and women who were employed locally and who resided either in Savannah or the surrounding communities. Many of these are still with us, and some are serving as supervisors.

With a group of officers who have the courage of of their convictions coupled with a broad vision, and the excellent work performed by our employees, the Savannah plant has enjoyed a growth that is almost unprecedented in American industry. In 1936 when the plant began operations, we employed between 500 and 600 people. The annual payroll was approximately 1 million dollars. We manufactured about 150 tons of finished product a day. Today we have 5300 employees, the payroll is just at 20 million dollars a year, and we are producing 1800 tons of finished product every day.

Together with the people employed by the wood contractors and wood dealers, who furnish us with more than 3000 cords of wood required daily in our operation, we estimate that approximately 9000 residents of Georgia are deriving their incomes directly from Union Bag & Paper Corporation. If we assume that the average family consists of four, this would mean that 36,000 are dependent for a livelihood on our operation.

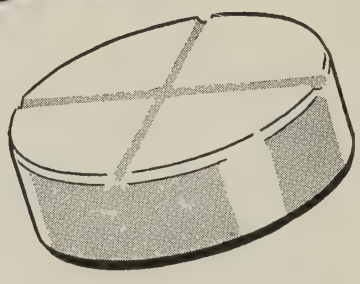
The cost of our pulpwood is in excess of 17 million dollars annually, and we distribute to the common carriers, such as the railroads and the truck lines, more than 15 million dollars in freight every year.

The Savannah plant of Union Bag is a permanent installation. It will be here for generations to come. Pulpwood, which we obtain largely from Georgia, is our principal raw material. To protect a tremendous investment, and in order to assure the plant's continued growth, it is necessary for us to have immediately available this product of the forest. To this end we have been acquiring timber land ever since the plant was built. We now either own or control nearly 1 million acres of forest land with virtually all of the major tracts located in the state of Georgia and practically all of these in those counties within a 100-mile radius of the plant.

Despite our rather large land ownership, we depend—and will continue to depend—on the private landowner for the big majority of our pulpwood. Because the small private landowner is the principal source of our wood supply, we feel an obligation to render him every possible assistance. This broadens our community

G. W. E. NICHOLSON, Executive Vice-President, Union & Paper Corp., New York, N. Y.

Vanzyme discs



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relations program to take in virtually all of the State of Georgia. It is important to us to work closely with the private landowner, to encourage him to protect his trees from fire and to cut them intelligently, and above all, to market his trees in a manner that will bring him the greatest return. To aid in this program, we set up in our woodlands division, a conservation department. This department is staffed by 12 carefully selected graduate foresters. These young men are located in various sections of the state and their services, which are free, are at the beck and call of the private landowner who desires counselling, guidance, or assistance.

Although we give a great deal of attention to the plant's physical properties, we recognize only too well that the human equation in any business is the most important. In the building of a stronger, more efficient organization, one which is capable of making progress and of maintaining leadership in the industry, we have brought into our organization a great number of men with university training and possessing varied specialized professional know-how to the extent that nearly 300 of our employees are college graduates.

Having provided you these facts as background, I would like to give you my interpretation of the part a progressive company should play in the community. Actually, there is no particular formula for success in building good relations with the community except that which is set up in the Golden Rule. Simply stated, good community relations stem from a matter of "doing unto others as we would have others do unto us," and in the manner in which we conduct ourselves.

It is also true that good relations outside of the plant grow from good relations inside the plant. In other words, a plant could not expect to enjoy good public relations until it first established good employee relations. This is basic because no amount of effort on the company's part can offset the harm done by disgruntled employees who complain to their wives and neighbors and others in the community about working conditions, wages, and other in-plant matters.

The success or failure of any organization depends upon the character and leadership of the management and its ability to build an effective team that will work happily together. I would like to outline a few of the guiding principles:

1. Locate and place the right people in the right places.
2. Train, develop, and educate every one for the job to be done.
3. Mold the organization into a well-coordinated team.
4. Supply the most up-to-date facilities and conditions.
5. Give opportunity, incentive, and recognition.
6. Look ahead, plan ahead for more and better things.

Any organization which has these principles as its foundation should be a credit to the community.

Community relations is a way of working and living together. If this is to be accomplished, the industrial employee must recognize his citizenship responsibilities by participating in community activities such as:

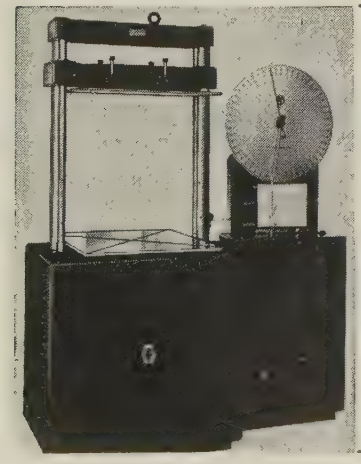
1. Taking part in civic affairs.
2. Being active in business and service organizations.
3. Sponsoring youth activities such as Boy Scouts, Girl Scouts, and other character building organizations.
4. Promoting the educational and cultural life of the community.
5. Cooperating with local authorities in meeting community problems.
6. Participating in local government.
7. Leadership in church and other religious or fraternal activities.

Industrial management today has a definite responsibility to the community and it must earn the respect, the friendship, and the confidence of its residents through leadership and active participation in all worth-while community undertakings. A successful program for building good community relations does not just happen—it springs from a sense of responsibility and must have the active support and cooperation of every one in the organization.

Any community relations program must of necessity be a long range program and it must give due consideration to every segment of the public. We have endeavored to accept our responsibilities to the community, and any contributions we have made in this direction are due in a great measure to the fact that we have been fortunate in bringing together and helping to develop a great number of employees who possess qualities required for accepting community leadership.

It always brings me great satisfaction to learn of the many outstanding, fine associates of mine who are giving their time and effort after working hours in order to do their share in bringing about a better and happier community and a more cordial relationship between the company they represent and the citizens of Savannah. I think that I can say in all truthfulness that there is hardly any activity for the good of the Savannah community in which you will not find some of my associates participating. That is as it should be.

Presented at a meeting of the Exchange Club in Savannah, Ga., May 9, 1955.



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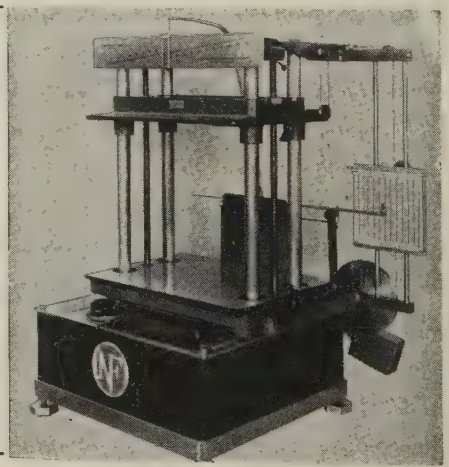
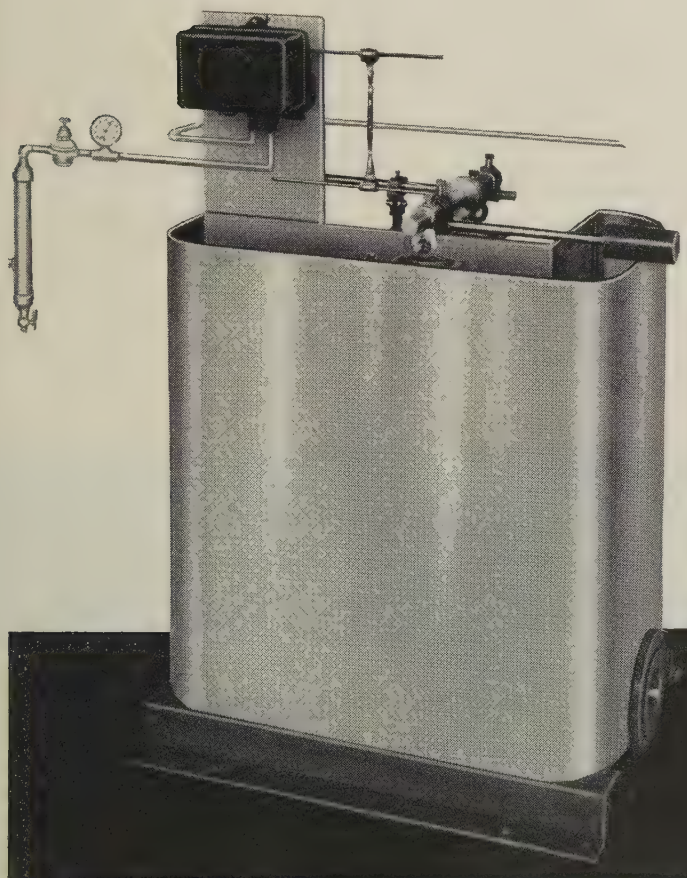


LET'S HAVE A LOOK AT THE RECORD

An occasional glance at the continuous chart record of incoming and outgoing consistency is enough to gladden the heart of every pulp or paper maker who is equipped with Bird Consistency Regulators.



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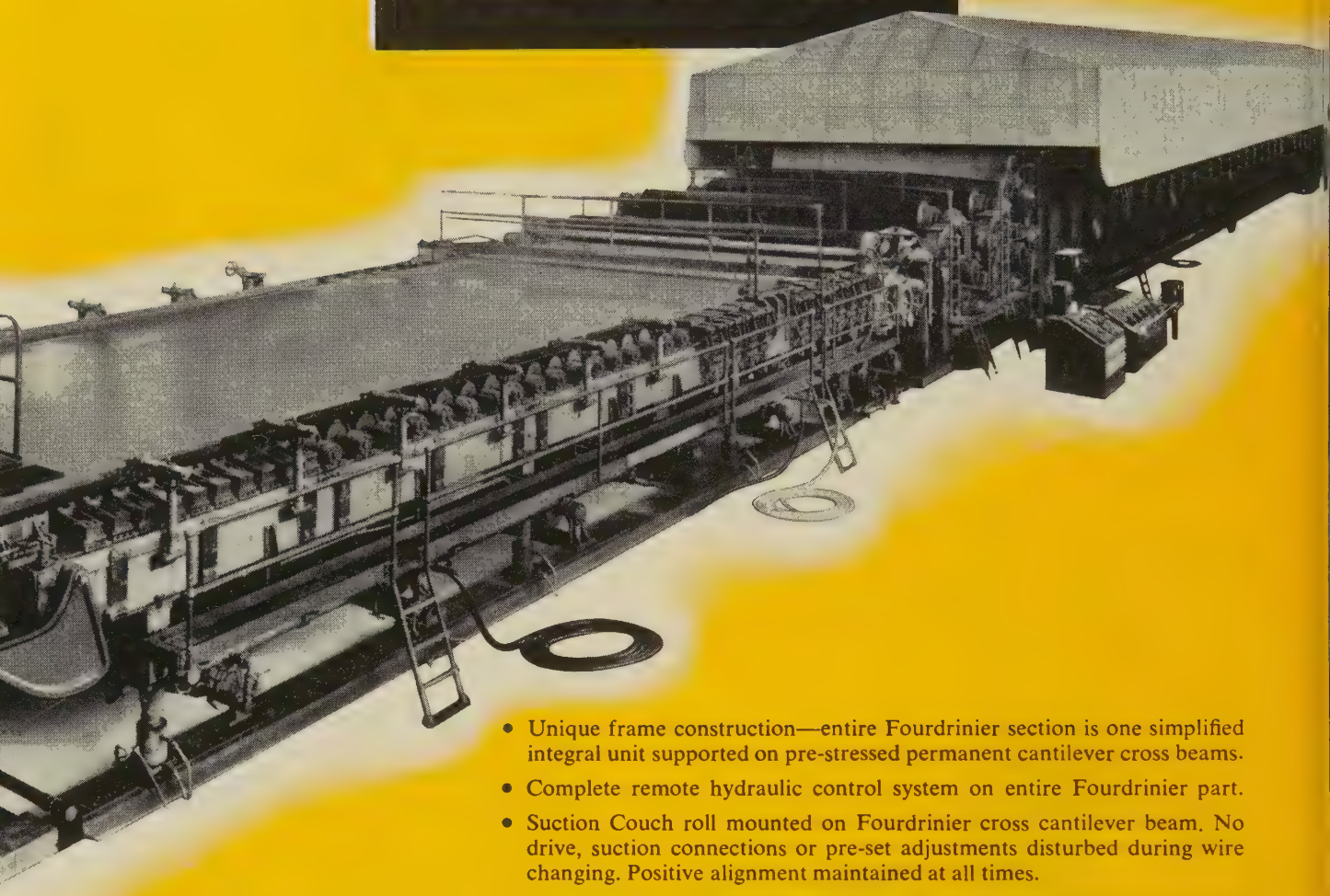

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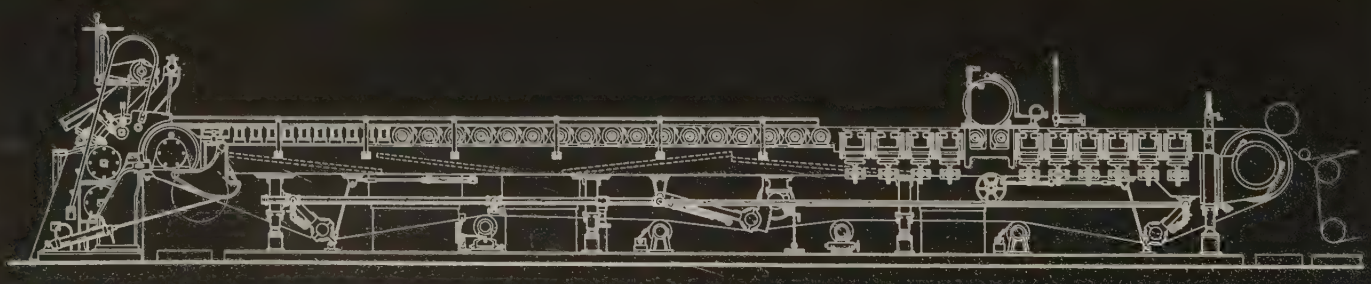

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Already five new, big, fast and modern Bagley-Sewall Fourdriniers of this design concept are giving increased production with lower operating costs and less maintenance in mills both here and abroad.

SUCTION COUCH ROLL

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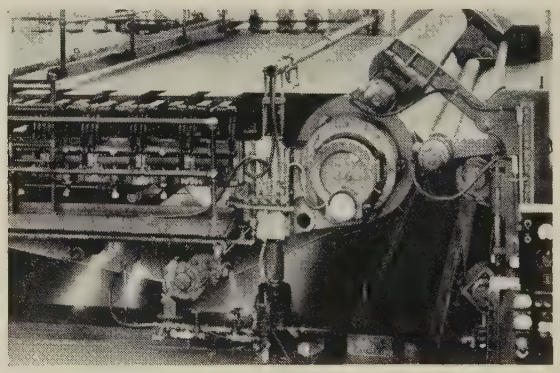

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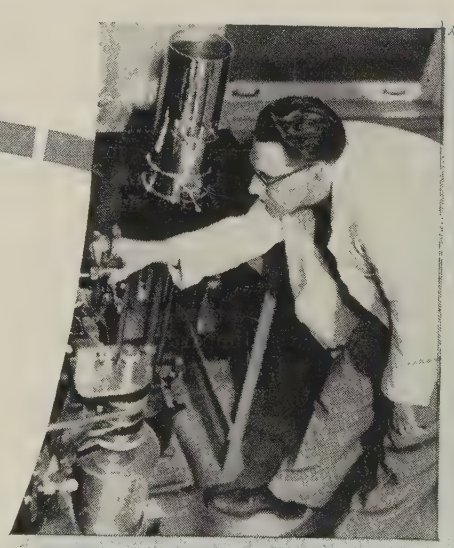

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WORLD PULP AND PAPER RESOURCES AND PROSPECTS—I*

THIS survey shows that world paper consumption, which averaged 47 million tons annually during 1950–52, is estimated to rise to 65 million tons annually by 1960–62. About 13 million tons of this increase will take place in Europe and North America. These two regions today satisfy a substantial proportion of the needs of the rest of the world. Though a considerable increase in production in these two regions is expected, the surplus available for export to the rest of the world is not likely to grow very rapidly.

The four less developed regions of the world—Latin America, the Far East, the Near and Middle East and Africa—together with Oceania, today consume about 4.5 million tons of paper. Of this, well over a third is imported from Europe and North America, as well as about half a million tons of pulp. By 1960–62 their paper requirements are expected to rise by close to 4 million tons.

Numerous new pulp and paper projects are now being built or under consideration in all these regions. Leaving aside developments in China and Japan, the expansion contemplated in the coming decade corresponds to just over half the expected increase in requirements.

The import needs of these regions will therefore rise, and the rate at which consumption increases in the next few years will be determined by the extent to which increased imports can be obtained and by the pace at which domestic production rises. In the longer term, unless efforts are made to encourage a more rapid expansion of domestic production, lack of adequate supplies of paper may hamper educational and cultural progress and economic advance.

All these regions, with the exception of the Near and Middle East, possess ample resources of fibrous materials suitable for papermaking. Recent technical advances have demonstrated the suitability for pulping of various grasses, agricultural residues and, in particular, of tropical hardwoods —the world's greatest single reserve of fibrous material. The obstacles to more rapid progress are, generally speaking, economic and environmental rather than technical. The present situation calls for more specific investigations aimed at encouraging the development of new capacity in favorable localities and at the same time reducing the risk of misinvestments.

The organs of the United Nations, and in particular the specialized agencies, have an important part to play. By assembling data of this kind, and by disseminating up-to-date information concerning the nature and extent of resources, pulping procedures and costs, trends in consumption and market developments, native and foreign private and public investors will be encouraged to interest themselves in further developments.

WORLD PULP AND PAPER PRODUCTION 1913 TO 1950–52

Between 1913 and 1950–52 the world's production of paper and board has nearly quadrupled. Throughout this period Europe and North America together have accounted for nine tenths or more of the world total; but whereas Europe's share in world production before the First World War was about half, today it is little more than a quarter. North America's share, however, has risen to 64%.

Table I. World Production of Paper and Board, 1913 to 1950–52

	1913	*1935–38*	*1950–52*
World total (Million metric tons)	11.8	27.9	46.9
Of which:			
Europe (Million metric tons)	5.9	11.1	13.1
(Percentage)	(50)	(40)	(28)
North America (Million metric tons)	5.1	14.2	29.0
(Percentage)	(43)	(50)	(62)
Rest of world (Million metric tons)	.8	2.7	4.7
(Percentage)	(7)	(10)	(10)

Since the years immediately preceding the Second World War, North American production has more than doubled, that continent accounting for nearly 15 million tons (or 79%) of the 19 million tons increase which has taken place in the last 15 years or so.

The geographical distribution of the world's production of paper and board corresponds roughly to the disposition of the world's resources of coniferous timber, today the most important pulping raw material. The main exception to this very general statement is the USSR, which, though possessing about two thirds of the world's total coniferous standing timber, produces less than one twentieth of the world's paper and board.

The world's pulp production is similarly concentrated, as shown in Table II.

Table II. Regional Distribution of Wood Pulp Production, 1950–52

Million metric tons

Region	*Average production 1950–52*	*Percentage*
Europe	10.94	29.5
USSR	(1.80)	(4.8)
North America	22.53	61.0
Latin America	0.35	0.9
Near and Middle East	0.02	
Far East	1.12	3.0
Africa	.07	.02
Oceania	.23	0.6
World Total	37.06	100.0
Of which:		
Mechanical	14.3	38
Chemical (except dissolving)	20.7	56
Dissolving	2.1	6

Thus Europe and North America produce 33.5 million tons of wood pulp out of a world total of 37 million tons. The four

* A portion of a survey prepared by the Food and Agriculture Organization in cooperation with the secretariats of the United Nations Educational, Scientific and Cultural Organization (UNESCO); the Economic Commission for Europe (ECE); and the Economic Commission for Latin America (ECLA). Because of its length, that part of the original report being published in *Tappi*, will appear in two parts. Those interested in the full report should refer to the publication with the same title, issued by the United Nations.

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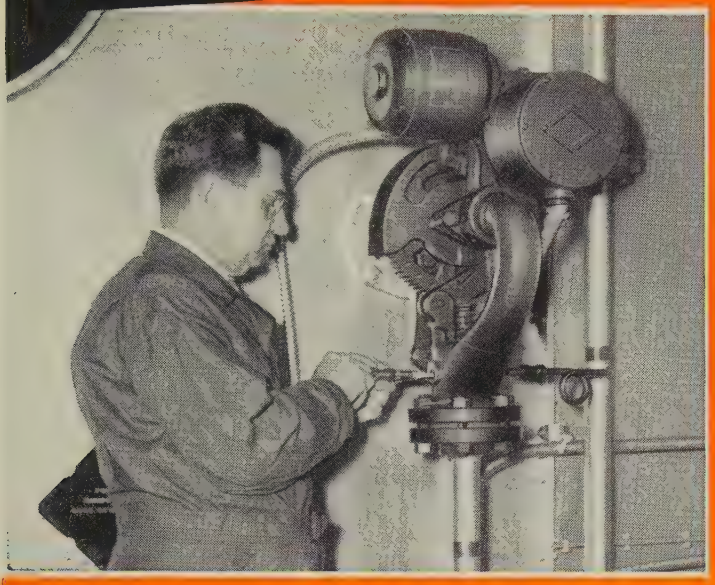

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less-developed regions, together with Oceania, produce less than 2 million tons between them.

In addition to wood pulp, the world's papermaking industries consume about 2 million tons of pulp of other fibers (straw, bamboo, grass, bagasse, etc.), nearly a million tons of rags, rope, etc., and over 12 million tons of waste paper. Most of the rags, (11 million tons of the waste paper and 1.25 million tons of the other fibrous pulps, nearly all straw) are consumed in Europe and North America.

Table III shows that Europe and North America between them today provide the rest of the world with about 2 million tons of pulp and paper in pulp equivalent annually.

Before the war, North America's net exports of paper were more than offset by an annual net import of a million tons of pulp. On balance, taking pulp and paper together, North America was a deficit region, satisfying part of her requirements by imports from Europe. All other regions of the world drew part of their supplies from Europe, the only region with a pulp and paper surplus. Though North American net exports of paper are lower today than before the war, the expansion of pulping capacity has reduced the region's dependence on Scandinavian pulp so that the region is almost self-sufficient in pulp. Taking pulp and paper together, North America has become a net exporter.

Europe's net exports of pulp have fallen by 750,000 tons, but net exports of paper have risen by 500,000 tons. Thus

Table III. Net Exports of Pulp and Paper from Europe and North America, 1937–38 and 1950–52

Million metric tons

	1937–38		1950–52	
	Pulp	*Paper*	*Pulp*	*Paper*
Net exports from:				
Europe	1.36	0.78	0.62	1.28
North America	−1.02	0.71	−0.08	0.48
Total net exports from Europe and North America to other regions:				
Pulp and paper	0.34	1.49	0.54	1.76
Total (in pulp equivalent)	1.6		2.0	

other regions of the world are now receiving from Europe and North America about 2 million tons of pulp yearly (either as pulp or as paper) as against just over 1.5 million tons before the war.

The composition by category of net exports of paper from the traditional producing regions to other regions of the world has not undergone any marked change, but Europe's share in the total is now nearly three quarters, as against about a half before the war.

Several features of (Tables III and IV) are rather striking; for example, the marked change in the North American pulp

Table IV. Net Exports of Paper from Europe and North America, 1937–38 and 1950–52

Million metric tons

	Newsprint	*Other paper*	*Board*	*Total*
Net exports from 1937–1938:				
Europe	0.31	0.42	0.05	0.78
North America	0.39	0.21	0.11	0.71
Total	0.70	0.63	0.16	1.49
1950–1952:				
Europe	0.53	0.64	0.11	1.28
North America	0.22	0.15	0.11	0.48
Total	0.75	0.79	0.22	1.76

balance, the expansion in European paper exports, and the fact that, though Canada alone produces well over half the world's newsprint, the less-developed regions' imports of newsprint are composed of 250,000 tons net exports from North America as against 500,000 tons from Europe. To assess the possibilities of these two regions increasing the amounts of pulp and paper they can make available to meet the rising needs of other regions, it is necessary to examine more closely the changes which have taken place there in the last two decades. Against this background we can then go on to examine the possibilities of increasing domestic supplies in other regions which today depend on these main production centers to satisfy a substantial part of their needs.

THE SITUATION IN THE REGIONS

Europe

Before the war, Europe was the only region† producing more pulp and paper than was consumed within the region. Not only were the less-developed regions of the world dependent on European exports of pulp and paper; even North America supplemented its own production by the import of a million tons of pulp from Northern Europe annually. The European pulp and paper industry suffered badly during the war, while in North America the industry made tremendous strides. But though North America is today no longer a deficit region, the European industry still makes the biggest contribution toward satisfying the needs of the rest of the world.

Can Europe continue to play her traditional role of supplier to the world's deficit regions? Is there any likelihood of increased amounts becoming available for export? These are the questions we must try to answer. To answer them we must trace the development of Europe's pulp and paper industry. This will be better understood if we glance first at the extent, distribution, and nature of the continent's forest resources.

In terms of forest area as a percentage of total land area, Europe is not ill-endowed with forests. With 28% of her land under forests, against 29½% for the world as a whole. Europe ranks behind the USSR and the Americas, but before all other regions. But because Europe is a highly industrialized and densely populated region, in terms of forest area per inhabitant Europe ranks lower than any other region. With but 0.3 hectare per head the continent is less well provided even than Asia (0.4 hectare per head); in other regions of the world, forest area per head ranges from 3.5 hectares in North America to 6.5 hectares in the USSR.

Three facts partly compensate for this relative lack of forests. First, virtually all the forest area in Europe is accessible and productive; today, virgin forests are almost nonexistent. Second, a high percentage of the forests consists of commercially useful conifers. Third, in most European countries the forests have been under careful, sound, and progressive management, supported and usually preceded by forest legislation for many decades past.

These attempts to manage the forests on sustained yield principles have on the whole been successful, though even in the best-regulated forests serious over-cutting has taken place from time to time, for example during war and postwar emergencies. The result of management efforts has been that the output of European forests since the beginning of this century has remained remarkably stable. The rising demand for in-

† In this survey Europe excludes the USSR, which is treated as a separate region, and Turkey, which is included in the Near and Middle East region. North America comprises Alaska, Canada, and the United States, all other Americas, including the Caribbees, being included in the Latin American region.

Africa comprises the African continent, i.e., it includes French North Africa as well as Egypt, Libya, Ethiopia, etc.

The Near and Middle East region runs from Cyprus and Turkey in the west to Afghanistan in the east. The rest of Asia, east of (and including) Pakistan, comprises the Far East region. Oceania includes the Pacific islands as well as Australia and New Zealand.

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Table V. Production and Trade in Wood Pulp and Paper, 1937–38 and 1950–52

Million metric tons—annual averages

	Wood pulp[a]		Newsprint		Other paper and board		Total paper and board	
	1937–38	*1950–52*	*1938–38*	*1950–52*	*1937–38*	*1950–52*	*1937–38*	*1950–52*
Production	10.99	10.18	3.01	2.64	8.60	10.47	11.61	13.11
Imports	3.29	3.14	0.70	0.43	0.82	1.19	1.52	1.62
Exports	4.66	3.76	1.01	0.95	1.30	1.95	2.31	2.90
Apparent consumption	9.62	9.56	2.71	2.11	8.12	9.71	10.82	11.82

[a] Excludes defibrated pulp.

dustrial wood has thus tended to press hard on the available supplies, and has only been satisfied, in the past, by steadily diverting to industrial uses wood formerly used as fuel and by importing from other regions considerable quantities of both roundwood and processed wood. As we shall see, the relative lack of forests in Europe is a fact of which we must take account in this survey.

Within Europe the forests are by no means evenly distributed. Of the total forest area of about 135 million hectares, over 50 million are found in Northern Europe (Finland, Norway and Sweden); here the forest area per inhabitant is over 3.5 hectares, more than ten times the average for Europe as a whole, and 78% of the forests consist of conifers. In the densely populated area of Northwestern Europe, less than 10% of the land area is under productive forests, and less than half of those forests consist of conifers; this area contains only 0.13 hectare of forest per inhabitant. In the Central European coniferous belt (Poland, Czechoslovakia, Switzerland, Austria and parts of France, Germany, and Italy), the forest area per head is only 0.3 hectare, though again 78% of the forests consist of conifers. In the rest of Europe (south and southeastern), though the forest area per inhabitant is not far below the European average, nearly three quarters of the forests consist of broadleaved species.

The pattern of Europe's forests has largely determined the location of Europe's wood pulp industry, which grew rapidly in the interwar period.

In 1921, at the end of the First World War, European wood pulp output was no more than 3 million tons, against 4.5 million tons in 1913; meanwhile, North American output had risen to 4 million tons. Between the wars, progress was rapid on both sides of the Atlantic, but faster in Europe. By 1937, Europe was producing 11.5 million tons against 10.5 million tons in North America. The Second World War brought a dramatic change. By 1946, output in Europe was no more than 5.7 million tons, while in North America it had risen to 15.5 million tons. Thereafter recovery was rapid, and by 1950 output in Europe had risen to nearly 10 million tons and in the peak year, 1951, reached 10.8 million tons. At the same time North American production continued to grow, reaching 23.4 million tons in 1951.

Some of the changes brought about by the war are reflected in Table V, which contrasts the levels of output and trade in pulp and paper before and after the war.

In 1950–52 wood pulp production was still 800,000 tons below the prewar figure. Net exports of pulp to other continents, however, had fallen by almost as much, so that pulp consumption in Europe was but slightly below the prewar level. Nevertheless, Europe produced 1.5 million tons more paper and board than she had done before the war. Exports to other continents rose by nearly 500,000 tons, and Europe itself consumed over a million tons more. These salient facts prompt three questions: Why is European pulp output still below prewar? How did paper production expand without a corresponding increase in pulp consumption? Why has the rise in European paper consumption been so modest compared with that which has taken place in other regions?

During the war, pulping capacity in Europe, far from expanding, was seriously reduced. Many mills and machines were destroyed; others suffered from the protracted arrears of maintenance; some capacity was lost as a result of the territorial adjustments which took place after the war. More serious, because more lasting, was the reduction in Europe's pulpwood supplies. Whereas the First World War had added 6.5 million acres to Europe's forest area, territorial changes after the Second World War led to the loss of 9 million hectares with an estimated annual growth of 15 to 20 million cubic meters. Many of the European forests had been seriously overcut during the war and immediate postwar years, and corrective action called for a reduction in annual fellings. For this reason, and also because of high domestic reconstruction needs, the prewar flow of timber from eastern and central Europe to western Europe was not resumed. The Soviet timber industry, hard hit by the ravages of war, faced a tremendous task in meeting the USSR's own needs for reconstruction, so that supplies of timber to Europe from the USSR (which before the war had included about 3 million cubic meters of pulpwood annually—equivalent to more than 500,000 tons of pulp) were no longer forthcoming.

In spite of all this, output of wood pulp climbed rapidly from the low level to which it had been reduced at the end of the war. Idle plants were repaired, and new capacity built. The proportion of total cut used for industrial purposes gradually improved. The shortage of coniferous pulpwood was partly compensated for by increased use of broadleaved woods (poplar, aspen, birch and beech) and by increased utilization of sawmill waste.

With less wood pulp available Europe nevertheless produced considerably more paper. Several factors made this possible. There was a striking increase in the recovery and repulping of waste paper; straw pulping capacity increased, and greater use was made of other nonwood fibrous materials. Part of the improvement in the pulp to paper ratio, however, was due to the fact that the share of newsprint (in whose production little substitution of other materials for wood pulp has yet proved possible) in total output had fallen. Newsprint capacity, it should be remarked, had been particularly badly hit by the war, and newsprint output in 1950–52 was still more than 300 thousand tons below the prewar level though production of other categories of paper and board had risen by nearly 2 million tons.

So far we have spoken of Europe as a whole. But, as the earlier sketch of the pattern of the continent's forest resources may have indicated, Europe's pulp industry is highly localized. Two thirds of Europe's output of pulpwood, nearly the same

Table VI. Regional Distribution of Europe's Production of Pulpwood, Pulp and Pulp Products, and of Consumption of Pulp Products in 1950

Percentage of total roundwood equivalent

	Pulpwood output	*Pulp output*	*Output of of pulp products*	*Consumption of pulp products*
Northern Europe	67	64	25	9
Eastern and Central Europe	17	11	12	11
United Kingdom	[a]	1	20	26
Germany	12	14	18	22
Northwest Europe	3	7	18	22
Southern Europe	1	3	7	10
	100	100	100	100

[a] Less than a whole number.

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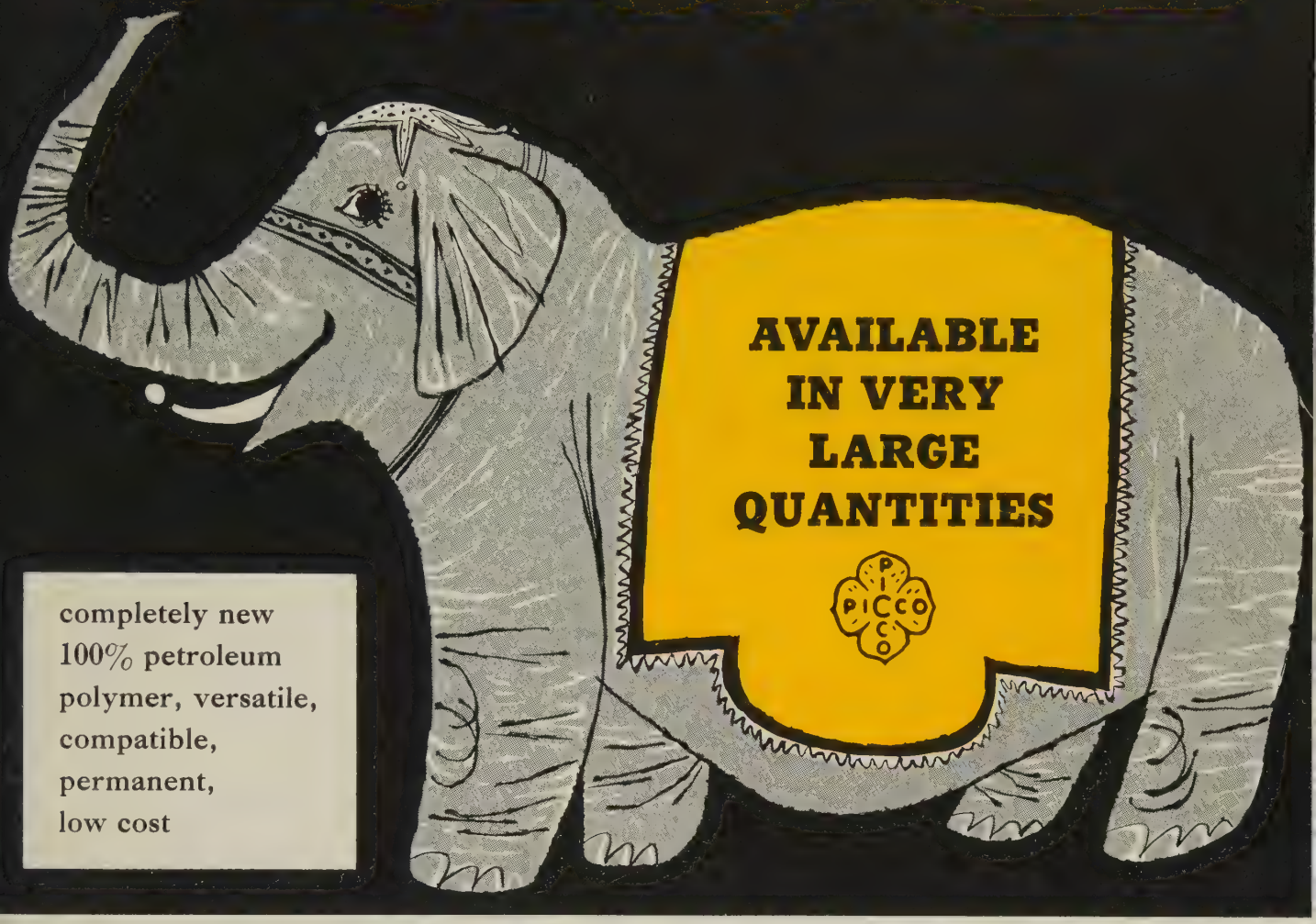

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proportion of its pulp production, and over one fifth of its production of paper and board are produced in the three northern countries, Finland, Norway, and Sweden, which together consume less than one tenth of Europe's total consumption of paper and board.

For reasons which have already been explained, there is today only a marginal trade in pulpwood, and there is therefore a close correspondence between the distribution of Europe's pulpwood production and its pulp output. It is this concentration which accounts for the fact that the three northern countries are responsible for over four fifths of all European exports of wood pulp and two thirds of all paper exports.

Well over half of Europe's paper production capacity is located in the United Kingdom, Germany, and Northwest Europe, where dense population and a high level of industrial activity concentrate demand. It was in these countries that papermaking on a large scale first began in Europe, in the days when rags were the principal raw material. With the advent of the wood pulp age, these countries retained their importance. Lacking domestic coniferous resources they came to depend increasingly on imported pulpwood and, more especially, on imports of pulp from Scandinavia.

During the war, cut off from their traditional sources of pulp, and compelled to concentrate on those sectors of their economies essential to the prosecution of the war, paper production dwindled and strict controls on the consumption of paper were introduced. Many of these controls were continued after the war when, for balance-of-payments reasons, it became necessary to limit import programs. In the United Kingdom, Europe's largest consumer and importer of wood pulp, not all the restrictions on paper consumption have yet been removed. The fact that the rise in pulp and paper prices as compared with prewar has been greater than for commodities, in general, has also tended to inhibit some of the rise in consumption that might have taken place. At the same time the need to earn foreign currencies, which is as strong in the papermaking countries of western Europe as in the pulp and paper surplus countries of northern Europe, has led to an increase in exports of paper from Europe to other continents; moreover, imports of Canadian newsprint have declined. Thus it is that Europe today, in spite of increased literacy and a higher level of industrial activity, consumes only 7% more paper and board per head than it did before the war.

Table VII. Apparent Consumption per Head of Paper and Board in Europe, 1937–38 and 1950–52

Kg. per head

	1937–38	*1950–52*	*Percentage rise or fall*
Newsprint	6.8	5.3	−22
Other paper and board	21.0	24.5	17
Total paper and board	27.8	29.8	7

While consumption of newsprint per head has declined by a fifth, that of other paper and board (including fiberboard) has increased. But these figures relate to Europe as a whole; they conceal the very disparate changes which have taken place in different areas of Europe.

Consumption per head of other paper and board has risen in all the areas distinguished save Germany, but more rapidly in the exporting countries than in the importing countries. Newsprint consumption per head has also risen in the exporting countries, while in the United Kingdom and other importing countries it has fallen. In the United Kingdom the fall has been precipitous, and newsprint consumption per head in that country is less than half prewar. The United Kingdom's share in total European newsprint consumption has fallen from 48% before the war to 31% in 1950–52.

In both Germany and the United Kingdom—Europe's two largest consumers—paper consumption has fallen, in total and per head. Elsewhere it has risen, though the rise in the importing countries has been relatively modest. The United Kingdom was before the war, and remains today, almost entirely dependent on imported pulp for its domestic paper production. Germany, though a leading pulp as well as paper producer before the war, imported much of its pulpwood supply. Today, it can no longer import on the same scale, and has thus not only become a considerable importer of pulp but is now one of the foremost countries in the pulping of temperate hardwoods.

Table VIII. Apparent Consumption per Head of Paper and Board in Certain Regions of Europe, 1937–38 and 1950–52

Kg. per head

	1937–38			*1950–52*		
	Newsprint	*Other paper and board*	*Total*	*Newsprint*	*Other paper and board*	*Total*
Northern Europe	11.0	43.4	54.4	12.7	64.9	77.6
Other exporting countries	1.1	7.6	8.7	2.4	11.6	14.0
United Kingdom	27.6	42.3	69.9	13.2	49.0	62.2
Germany	5.0	41.6	46.6	4.9	32.2	37.1
Other importing countries	4.7	12.0	16.7	4.1	17.6	21.7

A host of factors have thus been responsible for the diverse movements in total and per capita consumption levels in different parts of Europe: the geographical discrepancies between the location of pulpwood supplies, pulp industries, and papermaking capacity; the differing rates of postwar recovery and the uneven impact of balance of payments problems; the strain on the continent's raw material resources; and so forth. Some of these factors may prove more enduring than others. Their net effect is to make it difficult to foresee with any accuracy how demand for paper and board will evolve in the coming years.

Several attempts have been made, however, and the first comprehensive appraisal of the future level of demand for pulp and its products appeared in the joint FAO/ECE Study "European Timber Trends and Prospects" published early in 1953.

This study, after examining past trends in European consumption of timber in its various forms, formulated estimates of future requirements based on various alternative assumptions relating to the general level of economic activity and the course of wood prices in relation to those of other commodities which can replace wood in its various end uses. After comparing these estimates with the expected trend in wood production, it concentrated attention on estimates corresponding to the following two sets of assumptions:

1. That European gross product rises by 50% in the decade 1950–60 and is accompanied by a substantial rise in the relative price of timber, and

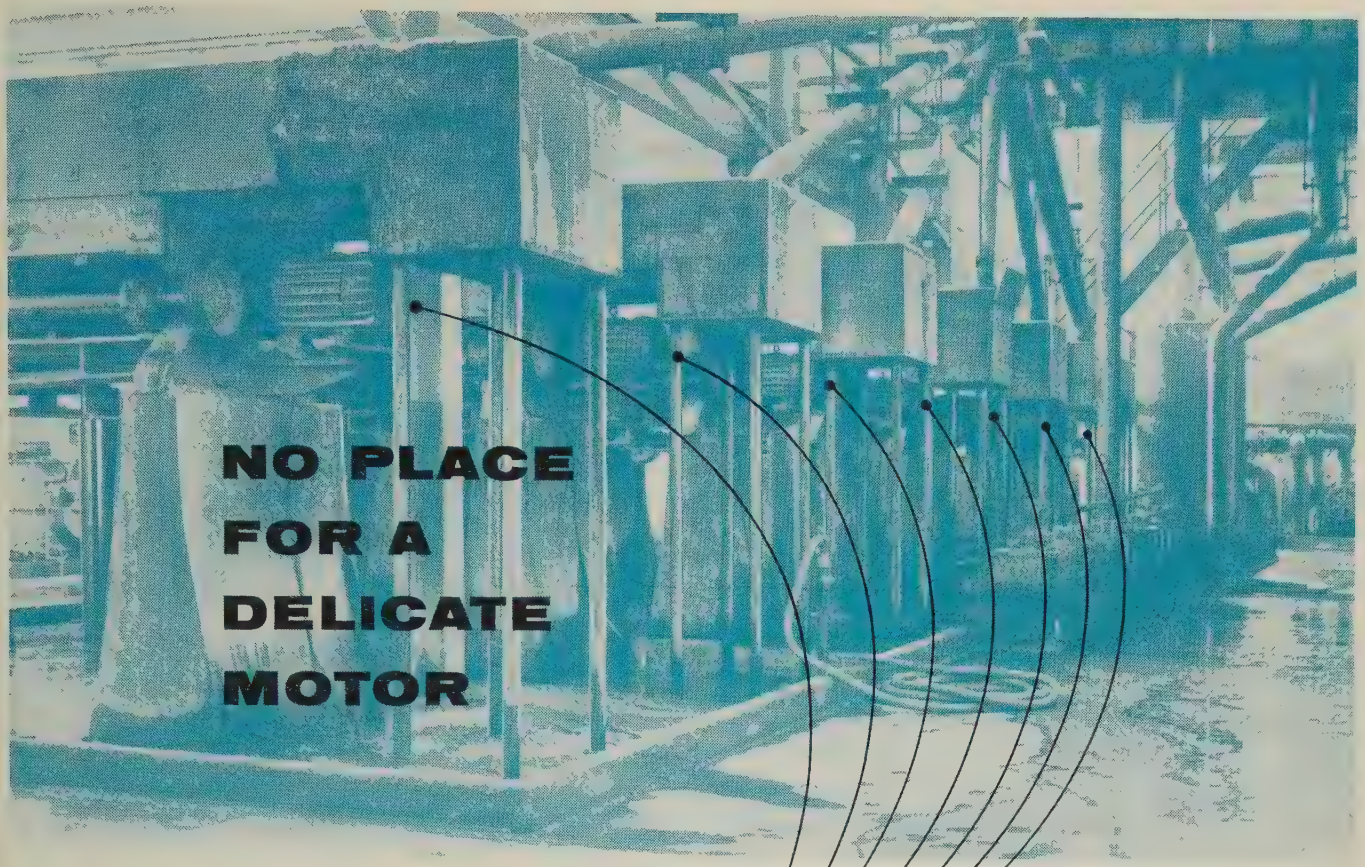
2. That European gross product rises by 20% during the decade and is accompanied by a slight rise in the relative price of timber.

Table IX. FAO/ECE Estimate[a] of European Pulp Products Consumption in 1960

Million metric tons

Category	*Estimated consumption 1950*	*1960*	*Percentage rise*
Newsprint	2.07	3.15	52
Other paper and board	8.56	12.10	41
Textile pulp	0.82	1.14	39
Total	11.45	16.39	43
Corresponding pulp needs	7.91	11.20	41

[a] Corresponds to assumption 2. Excludes fiberboard.



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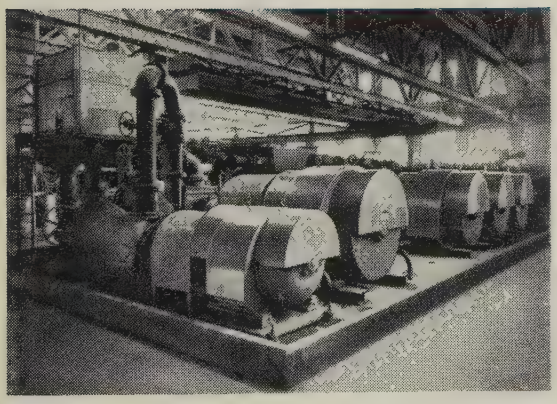

Five Elliott C-W splashproof motors driving various pulp refiners in a New England mill. The 250-hp, 1170-rpm motor in the foreground, drives a hydrafiner. Beyond are two 200-hp, 435-rpm motors driving jordans and two 200-hp motors driving unifiners.

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Table X. FAO/ECE and OEEC Estimates of Pulp Products Consumption in 1960 in OEEC Member Countries

Million metric tons

	1950		1960			
	Estimate of consumption		FAO/ECE		OEEC[a]	
	FAO/ECE	OEEC[a]	Estimated consumption	Percentage rise	Estimated consumption	Percentage rise
Pulp product						
Newsprint	1.75	1.60	2.70	54	2.52[b]	57
Other paper and board	7.14	6.60	9.73	36	8.92	35
Textile pulp	0.64	0.72	0.86	34	1.00	39
Total	9.53	8.92	13.29	39	12.44	39
Corresponding pulp needs	6.56	6.23	9.08	38	8.50	36

[a] Covers 92% only of OEEC Member Countries' consumption.
[b] Includes 0.5 million ton of newsprint stated to be conditional on increased imports from Canada. The pulp estimate includes a corresponding amount of pulp, after allowing for additional waste paper recovery.

The lower of these two estimates implies, as Table IX shows, a 43% increase in pulp products consumption and a 41% increase in corresponding pulp needs between 1950 and 1960.

It is rather striking that a more recent inquiry conducted by the Pulp and Paper Committee of OEEC, relating to future consumption of pulp products in OEEC member countries, yielded very similar figures (Table X).

Though the estimates for the several categories differ, both estimates imply a 39% increase in total consumption of pulp products in the OEEC member countries. The OEEC estimate of corresponding wood pulp requirements is slightly lower (36% against 38%), and reflects the Pulp and Paper Committee's expectation that straw pulp capacity will continue to increase more rapidly than wood pulp capacity, forming a somewhat larger proportion of total pulp capacity by 1960.

Pulp and paper production and consumption are expected to continue to rise more rapidly in countries not members of OEEC; this accounts for the fact that the FAO/ECE estimated rise for all Europe (43%) is higher than that for OEEC member countries only (39%).

In the present survey the lower of the FAO/ECE estimates has been accepted. Some adjustment has been made to the estimates for fiberboard consumption (fiberboard is not included in Tables IX and X) and the total estimates are taken as relating, not to the year 1960, but to average consumption in the period of 1960–62. The increases in consumption, total and per head, which these estimates thus amended imply, as compared with average apparent consumption in the period 1950–52, are set out in Table XI.

Table XI. Estimated Increases in European Consumption of Paper and Board, 1950–52 to 1960–62

	Total consumption, million metric tons			Consumption per head, kg.		
	1950–52	1960–62	Percentage rise	1950–52	1960–62	Percentage rise
Newsprint	2.11	3.15	49	5.3	7.3	38
Other paper and board	9.71	13.23	36	24.5	31.0	26
Total	11.82	16.38	48	29.8	38.3	29

This estimated rise in consumption of 38% is much less than the rise recorded in North America in any recent decade. Moreover it is considerably less than that which took place in Europe in the inter-war period; between 1925–26 and 1935–38 European pulp products consumption (expressed in wood pulp equivalent) rose from 5.2 to 8.35 million metric tons—a rise of 60%.‡ Nevertheless it would call for a substantial expansion of European pulp and paper capacity, especially if the continent is to continue to make a significant contribution to the needs of other regions. In the FAO/ECE study it was assumed that every effort would be made to maintain pulp and paper exports to other regions at their 1950 level—about 2 million tons in terms of wood pulp; to achieve this aim, and at the same time satisfy Europe's own requirements at the level estimated above, wood pulp capacity (excluding defibrated pulp) would need to rise by 2.5 million tons during the decade.

After reviewing reported investment plans in the various parts of Europe, the study concluded that the required expansion was likely to be achieved, though it was pointed out that should the rate of economic growth approach that postulated in assumption I cited above, it would be necessary, in order to satisfy the correspondingly more rapid increase in demand, to provide for a greater capacity expansion than was at that time contemplated.

However, the check which the European economy sustained in 1952 and early 1953 suggests that the rise in consumption will more nearly approximate to that indicated by assumption 2—the one adopted in this survey. In point of fact something less than 2.5 million tons of additional wood pulp capacity may be needed. First, because a more rapid increase in straw pulp capacity may reduce wood pulp requirements. (In the study it was assumed that straw and wood pulp capacity would expand at the same rates.) Second, because the adoption of continuous working in countries where this is not at present the rule can achieve a rise in output without a corresponding increase in nominal capacity. Certain mills in Sweden have recently changed over to continuous working; one mill reports a consequent increase in output of 20% as compared with the 15% rise expected.

Similarly, it would seem that paper and board capacity will, on the whole, be sufficient to satisfy requirements at the end of the decade. One doubt only need be expressed, but it is an important one, since it relates to newsprint. Of the million tons increase which is expected to take place in European consumption in the course of the decade, nearly half would occur in the United Kingdom. Newsprint capacity expansion plans so far as at present known, together with estimated expected increases in Eastern Europe, would add between 550,000 and 650,000 tons to Europe's total capacity by 1956 or 1957. Unless this rate of expansion is maintained in the later years of the decade, then the rise in newsprint consumption (especially in the United Kingdom) could only take place either at the expense of curtailing overseas exports or by importing substantially larger quantities of newsprint from Canada.

This additional pulp and paper capacity, however, will call for a substantial increase in pulpwood supplies; at the same time requirements of other categories of industrial wood are likely to rise, though less rapidly. The FAO/ECE study therefore indicated various means whereby Europe's output of industrial wood might be raised, both in the short term, to take care of immediate future needs, and in the long term, to provide for expected increases in requirements in subsequent decades. A Joint Working Party of the Timber Committee of ECE and the European Forestry Commission of FAO met in June, 1953, to consider the implications of the study, and in

‡ "European Timber Trends and Prospects," Table XXIII/17, page 260.

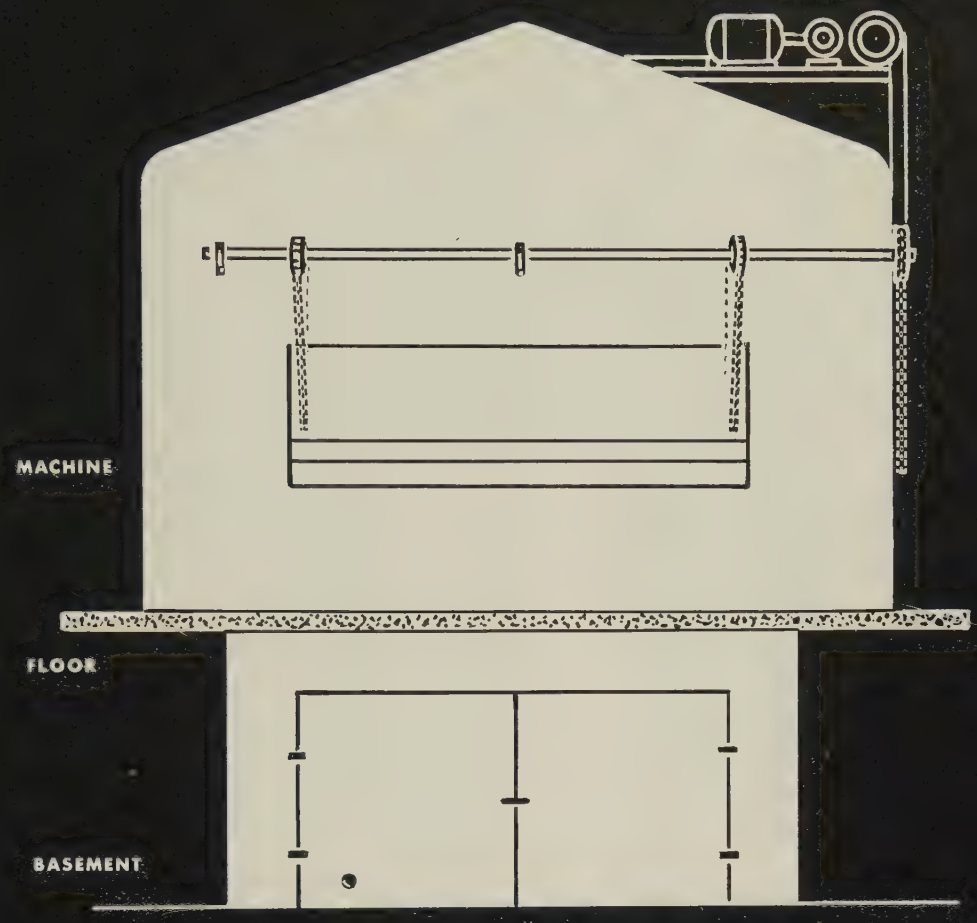

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Table XII. Europe's Net Exports of Pulp and Paper, 1937–52

Million metric tons

	1937	1938	1950	1951	1952	1937–38	1950–52
Net exports of:							
Wood pulp	1.65	1.08	0.90	0.68	0.30	1.36	0.62
Paper and board	0.97	0.59	1.41	1.43	1.01	0.78	1.28
Total	2.62	1.67	2.31	2.11	1.31	2.14	1.90

October, 1953, a joint meeting of these two bodies, attended by the delegates of 23 countries, agreed unanimously on a number of recommendations designed to relieve the strain on Europe's industrial wood supplies.

Among the measures advocated were the taking of modern forest inventories to lead to a more exact assessment of forest capital and annual growth; a re-examination of working plans, based on new inventories; intensified sylviculture and improved forest roads; reduced forest waste and improved wood utilization; and a considerable expansion in afforestation, reforestation, and forest improvement plans.

It is already clear that Europe's output of industrial wood in the coming years will be considerably higher than had been expected in 1951. New inventories have revealed in many countries an annual growth higher than had been assumed; and it has become clear that at least some of the earlier estimates of war-time overcutting had been exaggerated. At the same time a steadily increasing proportion of the total cut is being used for industrial purposes; the percentage used as fuel, which had risen as high as 53 in 1946, by 1952 had declined to 40, and is expected to fall to 39 in the near future.

Year by year more broadleaved wood is pulped; over 70% of the pulpwood consumed by the Italian pulp industry consists of nonconifers, mainly poplar, while Western Germany today pulps approximately 750,000 cubic meters of hardwood annually. More and more sawmill waste is being salvaged and used in the pulp mills, both in Scandinavia and continental Europe. The particular shortage of spruce pulpwood is being relieved by increasing use of pine.

Thus, a wide variety of measures which can help to stretch Europe's pulpwood supplies in the short term, bridging the gap until second growth forests planted in the inter-war period and being planted today approach maturity, are being increasingly applied. It may confidently be assumed that raw material limitations will not present an obstacle to the pulp and paper expansion which is expected to take place in the current decade.

It has already been remarked that by 1950 the European pulp and paper industry, in spite of its serious postwar difficulties, had succeeded in restoring its net exports of pulp and paper to other regions of the world almost to their prewar level. As Table XII shows, performance in the two succeeding years fell somewhat short of that in 1950.

In 1951, increased demand, reinforced by stockpiling requirements, led to increased European purchases and exports to other regions declined. The 1952 recession brought a weakening in demand in overseas markets as well as in Europe. A substantial recovery took place in 1953, however, and the measure of revival is indicated in Table XIII relating to exports from the three northern countries (which account for the bulk of European exports) and which includes estimated figures for exports in 1953.

Table XIII. Pulp and Paper Exports from the Three Northern Countries, 1937–53

Million metric tons

	1937	1938	1950	1951	1952	1953
Wood pulp						
Total	4.68	3.74	3.70	3.76	3.03	3.76
Of which to:						
Europe	2.91	2.45	2.75	2.94	2.39	2.90
North America	1.34	1.05	0.53	0.39	0.36	0.46
Other regions	0.43	0.24	0.42	0.43	0.28	0.40
Paper and board						
Total	1.62	1.28	1.85	2.05	1.62	1.97
Of which to:						
Europe	0.91	0.71	0.94	1.04	0.81	0.94
North America	0.28	0.23	0.17	0.20	0.18	0.23
Other regions	0.43	0.34	0.74	0.81	0.63	0.80

This table, besides showing that in 1953 exports had been restored to their 1950–51 level, brings out several interesting features of the northern countries' pulp and paper trade. Since the war the share of processed goods in total exports has increased. Pulp exports to North America, as noted earlier, have declined considerably. Comparing the figures in Table XIII with those contained in Table XII, we see that whereas the three northern countries account for almost the whole of the overseas trade in pulp, other European countries have a considerable share in the overseas paper trade. Finally, although pulp and paper production in regions other than Europe and North America has risen considerably since the prewar years, exports to these regions from northern Europe have increased.

What conclusions can be drawn from the foregoing discussion regarding the possibilities of Europe's traditional contribution to the pulp and paper needs of the deficit areas being maintained or increased in the future?

Essentially its contribution will depend on three factors, none of which can be predicted with any certainty. Clearly it will depend on the extent to which expanding output succeeds in maintaining a surplus available over and above Europe's own requirements. Several uncertainties underlie this truism. Though intra-European trade ties in pulp and paper are strong and of long standing, they are not in every case and in all circumstances dominant. The need for extra-European exports, on the part of both the pulp-surplus countries of northern Europe and the pulp-deficit but paper-producing countries of western Europe, is also strong. A variety of consumption and export controls, supplementing or counterfeiting the normal working of the price mechanism as necessary, could, in the interests of maintaining overseas exports, inhibit some of the rise in European consumption that might otherwise take place. Against this it has to be borne in mind that while European producers will make every effort to maintain and expand their overseas markets, they are not likely to undertake additional expansion schemes aimed primarily at satisfying an increase in overseas demand. The possibilities of North American competition, the increasing disposition of less developed countries to exploit their indigenous resources, and the fear of interruptions to markets due to trade and payments fluctuations, are all considerations tending to induce caution.

The second factor, scarcely less unpredictable, is the share of the European surplus which will be claimed by the United States. The prewar North American pulp deficit of about a million tons, met by imports from Europe, has given way in recent years to a position of approximate balance, with, in fact, a slight but perhaps fortuitous net export in the years 1951 and 1952. Europe will continue to export certain quantities of particular pulp grades to the United States; over and above this, the extent to which Europe will be called upon to supplement North America's domestic pulp supplies will depend very much on the level of economic activity and of pulp products demand in the United States. The present recession

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—says William Louden, Director of Product Development at Paterson Parchment Paper Company

"We were the first to recognize the value of Du Pont 'Quilon' chrome complex for adding grease resistance to special vegetable parchment papers," continues chemist Louden. "'Quilon' not only stops oil crawl, but also greatly reduces penetration and staining. Treatment with 'Quilon' has enabled Paterson to introduce a new family of vegetable parchments which are light in weight and economical to use in commercial packaging."

PERHAPS "QUILON" CAN IMPROVE YOUR PAPER PRODUCTS. Water solutions are economical and easy to apply to the sheet by size press, spray, transfer or immersion—no special techniques are required. For more information on Du Pont "Quilon" and its use in the paper field, clip coupon below.

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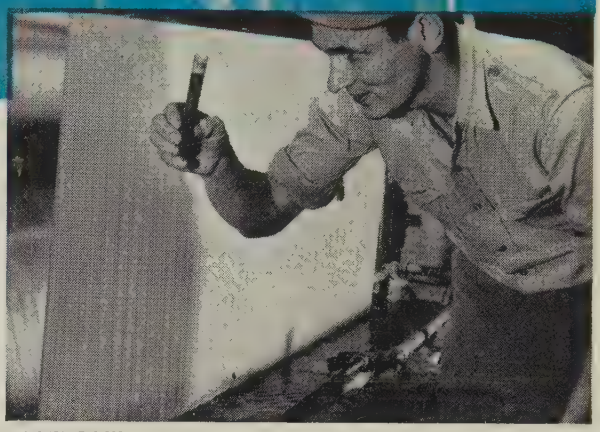
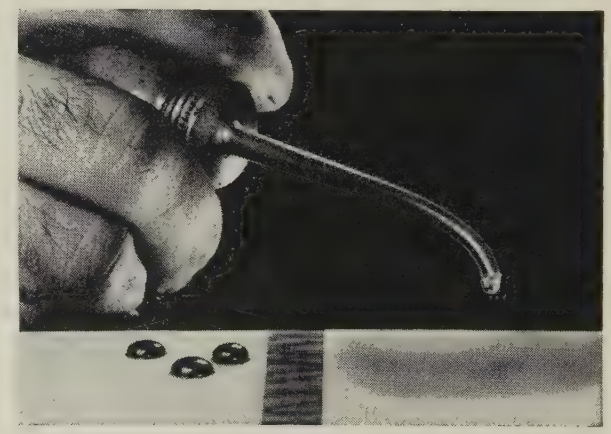


"QUILON" also adds water repellency and release properties to the high wet strength of "Patapar" vegetable parchment. Here it's being applied.



OIL-DROP TEST shows how parchment treated with "Quilon" (left) stops oil crawl . . . resists penetration and staining. Oil spreads and crawls on conventional grease-resistant parchment (right).

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Table XIV. North American Production and Consumption of Paper and Board, 1950–52

Million metric tons

	North America			Percentage of world total		
	Newsprint	Other paper and board	Total	Newsprint	Other paper and board	Total
Production	5.96	23.08	29.04	63	62	62
Net exports	0.24	0.23	0.47	..	..	..
Apparent consumption	5.73	22.85	28.57	62	61	61
Consumption per head, kg.						
North America	34.0	135.8	169.9			
Rest of world	1.6	6.5	8.1			
World	3.9	15.4	19.3			

may prove neither serious nor lasting; but there are indications that United States pulping capacity has become slightly, if temporarily, overexpanded. A marked upswing in demand later in the decade could cause the North American continent to again draw substantially on European supplies. Subject to this proviso, however, it would seem that, in general, European net exports of pulp to North America are likely, as in 1950–52, to remain well below the prewar level, and that the bulk of the surplus available for export overseas will find markets in the less developed regions.

Finally it is recognized that there may be a limit to the capacity of the less developed regions to import European pulp and paper. In the past the general pattern of international trade was a flow of manufactured goods from Europe and North America to Latin America, the Far East, etc., in exchange for raw materials and foodstuffs. Since the war, consumption needs have reduced the amounts of foodstuffs and raw materials which have been available for export. Up to 1952, this trend was partly compensated by favorable terms of trade, but since that year the terms of trade have deteriorated. Moreover there is a clear tendency already in Latin America for capital goods to play an increasingly important part in the total import program. The economic development of other regions will call for a similar shift in the pattern of their imports. Thus, however steeply pulp and paper requirements in these regions may rise, the volume of these commodities which they will in fact import from Europe will be conditioned, first, by their total capacity to import, and, second, by controls designed to change the pattern of import programs.

Our general conclusion must therefore be that while European exports of pulp and paper to the less-developed regions will continue, and are likely to return to and even exceed the 1950 level, it would be unrealistic to count on a substantial expansion in the coming decade.

North America

North America consumes 61% of all the paper and board produced in the world today. Practically all is produced within the region itself, and imports from and exports to other regions are small in comparison with North America's own

Table XV. North American Production of Pulp and Paper, 1913–52

Million metric tons

	Wood pulp			Paper and board		
	Canada	U.S.A.	Total	Canada	U.S.A.	Total
1913	0.77	2.6	3.4	0.6	4.7	5.3
1920	1.8	3.5	5.2	1.1	6.5	7.6
1929	3.6	4.4	8.0	3.1	10.1	13.2
1937	4.6	6.0	10.5	4.2	11.7	16.0
1946	5.8	9.6	15.5	5.3	18.4	23.6
1950	7.7	13.5	21.2	6.3	20.7	27.0
1951	8.5	15.0	23.4	6.5	23.6	30.1
1952	8.1	15.0	23.0	6.5	23.0	29.5

Table XVI. North American Trade in Pulp and Paper, 1937–38 and 1950–52

Million metric tons

	1937	1938	1950	1951	1952
Wood pulp					
Imports	2.19	1.57	2.20	2.18	1.81
Exports	1.08	0.63	1.76	2.20	1.94
Net imports (−)	−1.11	−0.94	−0.44	..	..
Net exports (+)	..	..	..	+0.03	+0.14
Paper and board					
Imports	3.10	2.13	4.57	4.72	4.75
Exports	3.89	2.41	4.83	5.25	5.35
Net imports (−)					
Net exports (+)	+0.79	+0.28	+0.26	+0.53	+0.60

production and consumption. The absolute amounts involved, however, are sufficiently large to be of some importance in inter-regional trade. Producing 62% and consuming 61% of the world total, North America has a per capita consumption, of newsprint and other paper categories, 20 times that of the average of the rest of the world. These few facts epitomize the uneven contemporary distribution of the world's paper supplies. This distribution, of course, is simply a reflection of the contemporary pattern of effective demand. This contrast carries no implication of any hogging of supplies by the North American continent; it is in fact as marked in years of easy supply and moderate prices as in years of shortage and high prices. The comparative figures set out in Table XIV do serve to emphasize, however, the great potentials which lie ahead for the low consumption regions. If we turn to wood pulp, the continent's dominance is no less marked; North America produces 61% per cent and consumes just under 60% of the world total.

The rise in North American pulp and paper production in the last four decades has indeed been phenomenal, as Table XV shows.

Paper and board production has increased nearly sixfold in four decades; it has almost doubled in the last 15 years. Between 1937 and 1946, a period which included the war years, production of paper increased by 7.5 million tons and that of pulp by 5 million tons.

Nevertheless, in spite of this rapid increase in production, the region has remained until quite recently a net importing region on balance, counting pulp and paper together.

Since the war there has been, as before the war, a small net export of paper and board, amounting to over 500,000 tons in 1951 and 1952 (Table XVI). In pulp the situation is rather different. Before the war the region imported net about a million tons of pulp annually (from northern Europe); since the war this has given way to a position of approximate balance and in the years 1951 and 1952 there was a small net export. Thus, in spite of the high level of pulp and paper production in North America, this region has not, until quite re-

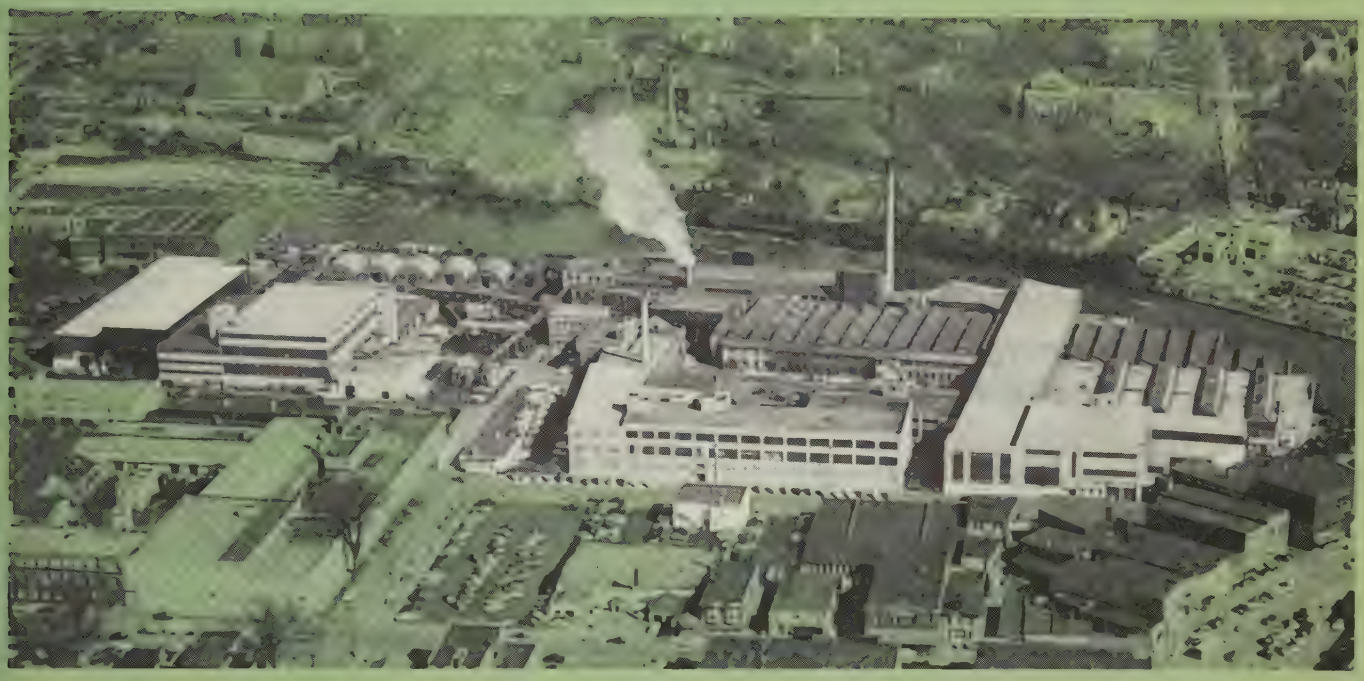
Table XVII. North American Trade in Pulp and Paper, 1950–52

Million metric tons

	Wood pulp	Newsprint	Other paper and board
North American exports to:			
North America	1.57	4.34	0.11
Europe	0.28	0.10	0.08
Other regions	0.12	0.28	0.27
North American imports from:			
North America	1.60	4.32	0.13
Europe	0.46	0.17	0.05
Other regions	..	..	0.02

The Beloit Album

Beloit Iron Works from the air; conferences with friends; quality control. Newsworthy personalities and events in the world of paper, as seen by the Beloit camera's roving eye



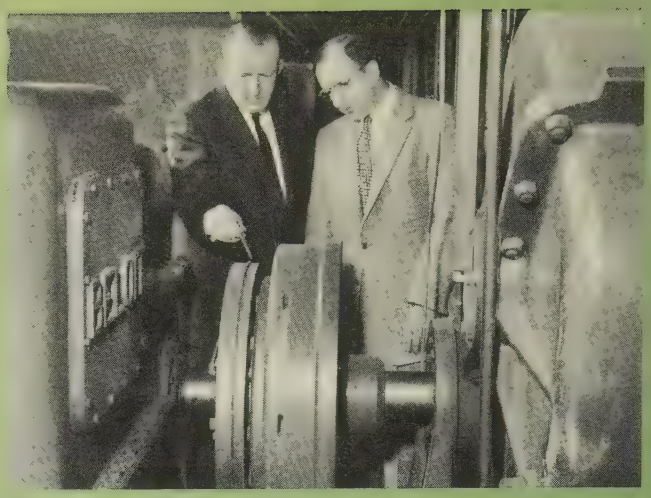
HISTORIC ROCK RIVER forms the eastern boundary of Beloit Iron Works, at Beloit, Wisconsin. Further east across the river is the campus of Beloit College, some of whose buildings can be seen at the top of the photograph. Beloit College was founded in 1847, Beloit Iron Works in 1858. The aerial view shows plant's 16-acre site. Total floor area: 660,000 square feet.

FROM FINLAND three Enso-Gutzeit Co. officials visit Beloit: president William Lehtinen, Lauri Alanko, Pentti Halle. Mr. Lehtinen is shown *(seated, right)* with Beloit chairman, E. H. Neese. Standing: A. G. Olson, Mr. Alanko, H. C. Moore, C. R. Whipple, and Mr. Halle.

SCOTT PAPER CO'S vice-president J. L. Ober and chief engineer A. J. Karpinski discuss new mill installations with members of Beloit Iron Works during a recent visit to Beloit. *(l. to r.)* C. E. Macklem, Mr. Karpinski, H. C. Moore, E. D. Beachler, Mr. Ober, and B. L. Hammill.

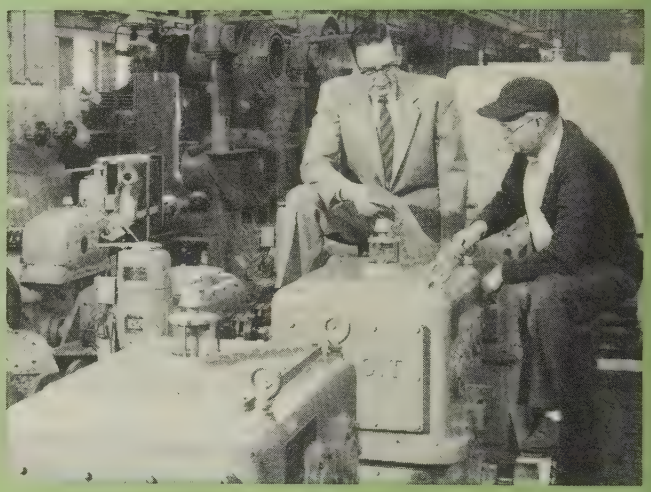
The Beloit Album

Behind the start-up of every paper machine is a record of many men, miles, and machine tools. The Beloit Album brings you some of the highlights, with emphasis on the human factor—for the finest machine is, after all, the product of many hands and minds. Reports from Beloit personnel literally come from "all over the map"—from T. J. Burns, Beloit's Southern representative; from R. A. Goodwillie, of the West Coast office; from G. J. Bertrand, of Beloit's Paris office, covering Central and Southern Europe and the Scandinavian countries; and many others. Customers visit Beloit, too, as is shown in the accompanying pictures. Personal contact is essential. In our book, it is also one of the pleasantest parts of the job—enabling us to meet friends, talk over problems, and make Beloit more truly "*your partner in papermaking.*"



ROME KRAFT'S general superintendent L. C. Crowder *(right)* and Beloit's Southern representative, T. J. Burns, examine a differential drive unit on the new Beloit 252" Fourdrinier Board Machine at Rome Kraft Co., Rome, Ga. Differential units link sections of machine mechanically.

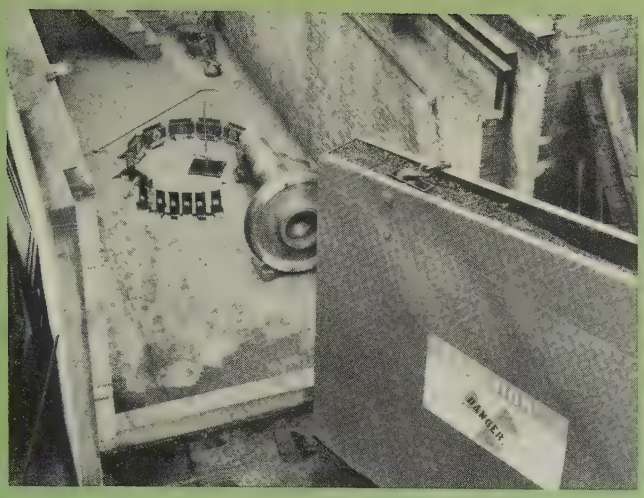
WET END REBUILD is here being discussed by E. A. Crawford, engineering manager of the Continental Paper Co., with C. R. Whipple, Beloit sales engineer. Individual attention to each customer's requirements is the primary consideration of the men who directly contact the mills.



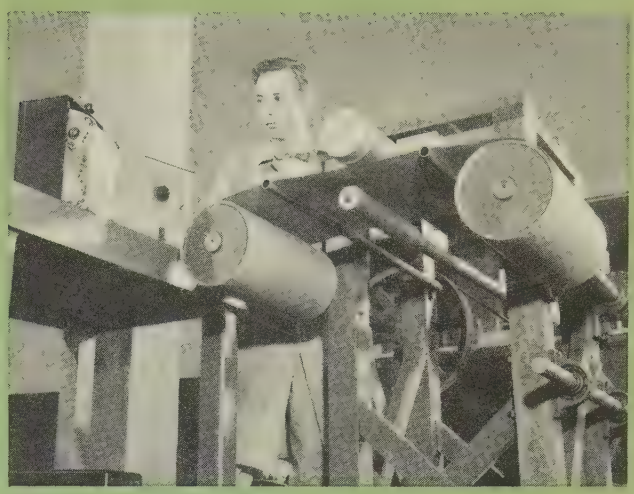
CUSTOMERS' NEEDS get personal attention of D. R. Schamp, Beloit sales engineer, and R. F. Foslin, assistant foreman, shipping floor, here shown looking over a shipment of differential drive units. Daily schedule requires continuous supervision of mills' requirements.

CANADIAN VISITOR R. L. Fraser, resident manager, Manitoba Paper Co. Ltd., discussing a machine rebuild with E. S. Skinner, asst. chief engineer, F. G. Ramsden, asst. sales manager, and L. E. Dennis, staff engineer in the engineering department at Beloit Iron Works.

IMPROVED TISSUE DRYING discussed. Seated *(l. to r.)*: R. Cowles, Marathon-Green Bay; J. Spalding, Marathon-Menasha; F. Nienow, Marathon-Menasha. Standing: B. L. Hammill; E. D. Beachler; H. W. Gochnauer, Marathon-Menasha; R. Robilliard, Marathon-Green Bay.

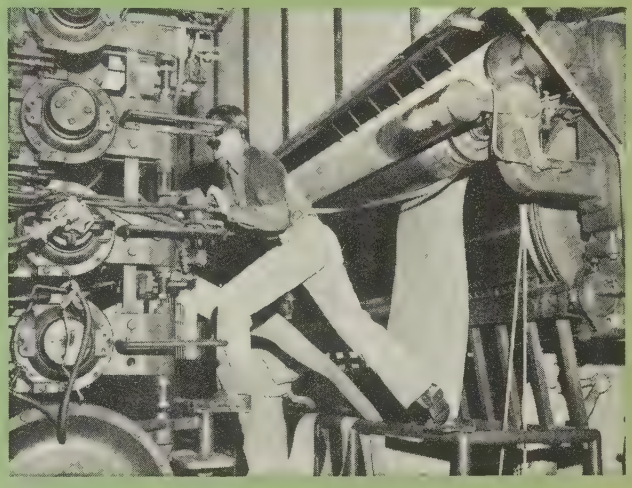


RADIOGRAPHIC INSPECTION includes use of Radioisotope Cobalt 60 in foundry quality control at Beloit Iron Works. Castings are being checked in the above setup, one of the standard procedures to insure continuous improvement in Beloit casting quality and design.

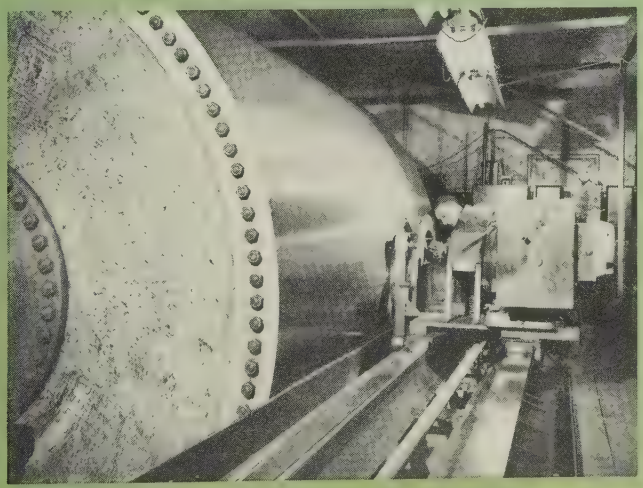


BETAMETER in Beloit's research and development department, operated by J. F. Atkins, measures variation in basis weight of sheet samples taken from Beloit machines running in the field. Testing of this type is only one phase of Beloit's never-ending design development.

READY TO ROLL: E. Lindberg *(center)*, master mechanic, and J. Rouman *(right)*, chief engineer, Combined Locks Paper Co., are shown by R. R. Olson, chief of Beloit's service department, how dryers are tested and loaded on flat cars for safe delivery to the mill. (See next page.)



FAST FOOTWORK and skill on the part of machine tenders is required in the eagle-eye process of starting up. Above, operators are shown "passing the tail" from dryer section into the calender of the new Beloit 252" Fourdrinier Board Machine at Rome Kraft Co., Rome, Ga.



PRECISION PLUS: B. R. Martin's years of experience have made him a versatile grinder operator. Not only does he operate the Yankee dryer grinder at Beloit, but he is a familiar figure in Beloit customers' mills, doing grinding work on all types of rolls and dryers.

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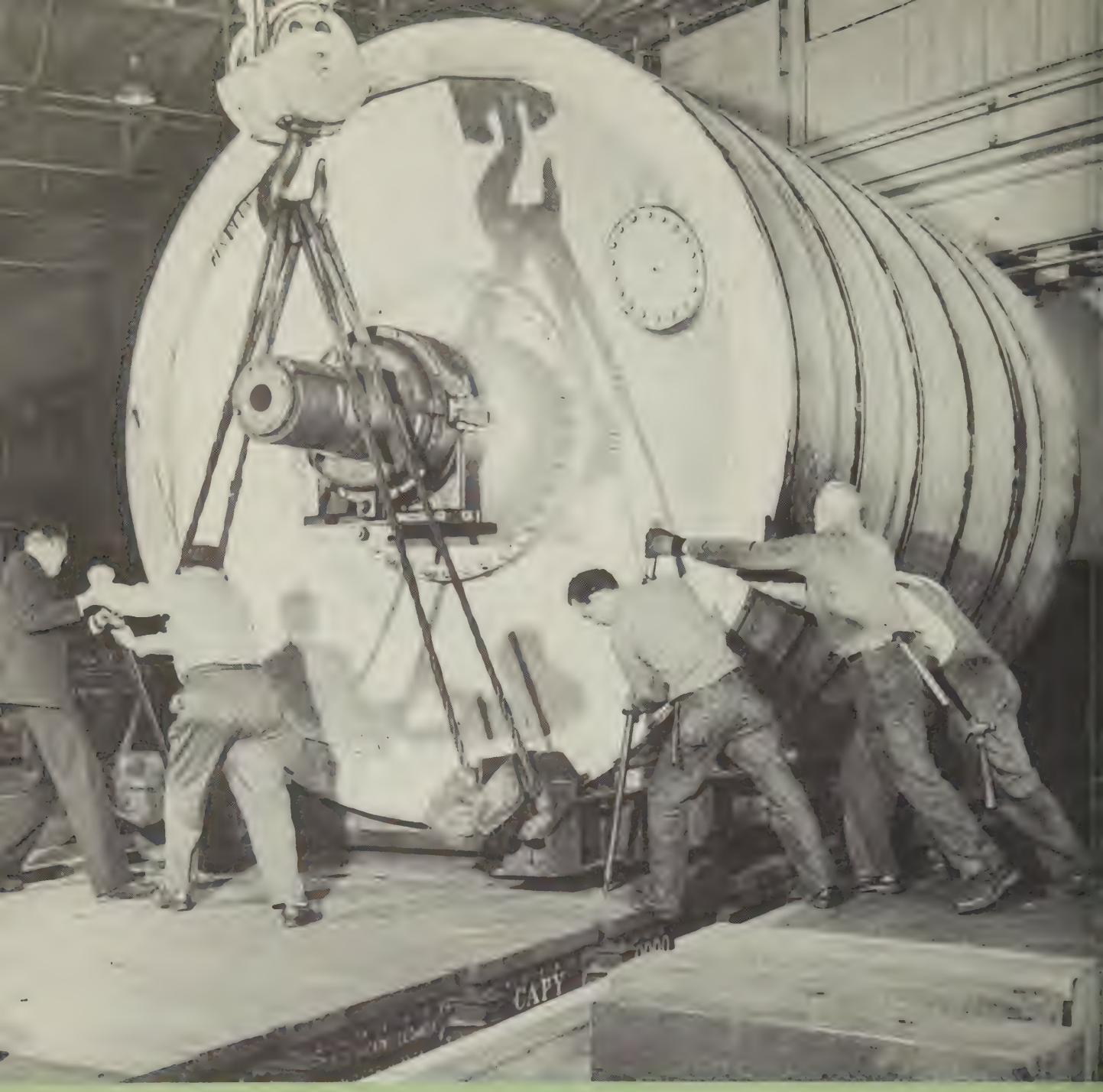

IT'S A BIG JOB, loading a Yankee dryer, but Beloit's shipping department has yet to be baffled by a behemoth. A 12-foot Yankee like the one above has a total weight of 92,000 pounds and must be placed on a flat car with exacting care. A 75-ton bridge crane lifts the huge cylinder from the adjacent Yankee dryer grinder and places it in line on the car. The dryer is then moved inch by inch until it is centered and balanced. Heavy steel bands are passed over the shell and journals and bolted down to prevent forward or lateral movement. Each time a Yankee is shipped, special arrangements must be made with the railroads, since a Yankee dryer loaded on a car measures 16'-5" from rail to clearance and is over 12 feet wide. Each Yankee must be specially routed to avoid any obstructions along the right-of-way.

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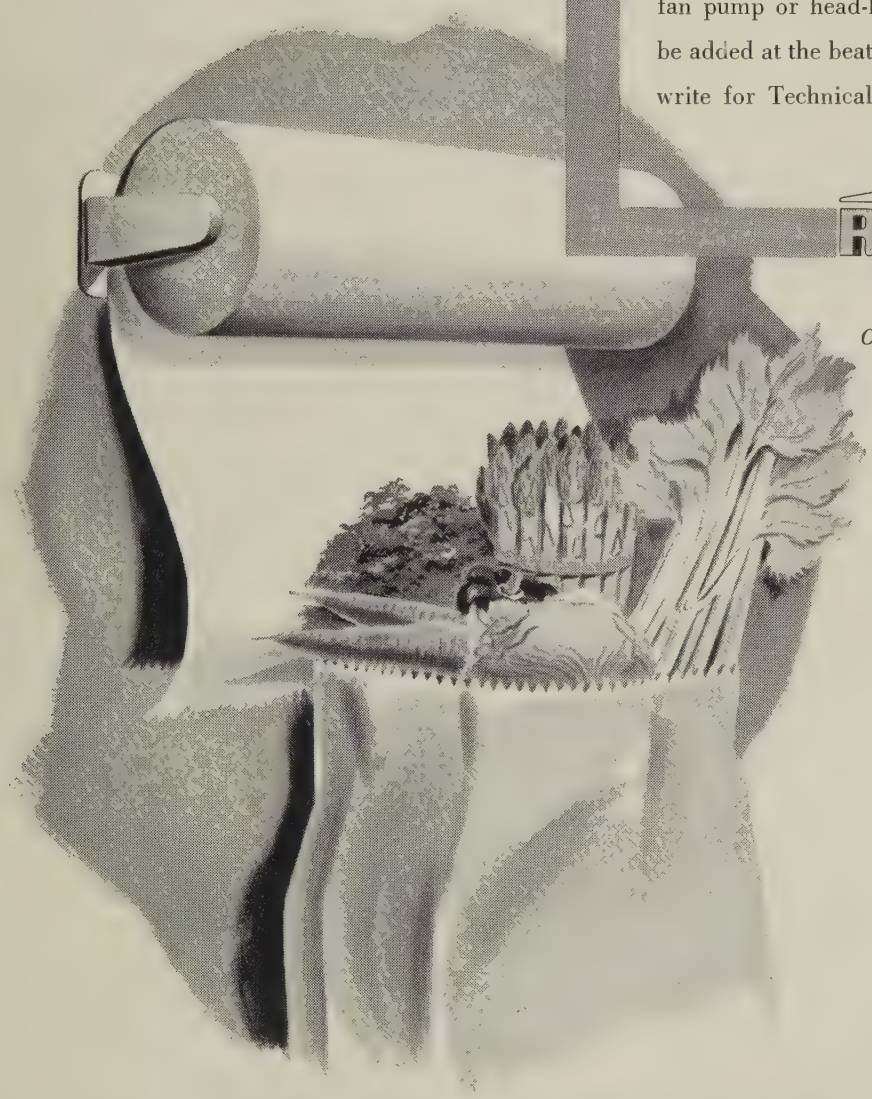

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Table XVIII. United States Imports of Pulp and Newsprint from Canada[a]

	Wood pulp			Newsprint		
		As percentage of			As percentage of	
	Total, million metric tons	All imports, %	All supplies, %	Total, Million metric tons	All imports, %	All supplies, %
1937–38	0.54	29	7	3.30	90	68
1950–52	1.26	62	8	5.48	96	79

[a] Including Newfoundland.

cently, made a net contribution to the needs of the deficit areas; indeed, before the war, it drew largely on the European surplus.

The net figures, however, somewhat understate the actual volume of trade between North America and other regions; they also conceal the considerable trade which takes place within the region.

Thus, while production in North America has risen sufficiently rapidly to satisfy the spectacular increase in consumption, and even to diminish the region's dependence on external supplies, it has not, so far, provided a substantial balance for export to other regions. The trade exchange with Europe (principally Canadian newsprint to Europe and European pulp to the United States) remains important, but less so than before the war. The main bulk of North American trade, however, takes place within the region, and consists almost entirely of heavy shipments of newsprint and pulp from Canada to the United States.

The United States' dependence on Canadian pulp (Table XVIII), in terms of the proportion of total supplies which is drawn from that source, has not changed much, though the actual amount imported has more than doubled. But 79% of her newsprint supplies, as against 68% before the war, come from Canada. In fact, the increase in the consumption of paper which has taken place in the United States could not have been conceivable had not the United States been able to draw freely on Canada's vast forest resources, well suited for the manufacture of pulp and paper, and especially for the manufacture of newsprint. Canada is by far the largest market for United States exports, and it has been remarked recently that 1 out of every $4.00 used to buy United States goods comes from the sale of Canadian newsprint. This serves to underline the extent to which the Canadian pulp and paper industry is directed toward the United States market.

Because the level of both production and consumption in North America is so high, the balance between the two, though marginal for North America, assumes considerable importance in interregional trade; its future course cannot be left out of account in considering the pulp and paper problems of the less developed regions of the world. It is therefore necessary to consider whether the rate of increase in North American consumption will be sustained, and whether it will be matched by a corresponding increase in capacity. Disharmony between the two trends could have the effect either of increasing the region's call on European supplies (at the expense of the needs of other regions) or of giving rise to a surplus capacity available for export production which might be significant in relation to the needs of the rest of the world.

Pulp and paper consumption trends have, not unnaturally, been more closely studied in the United States than in Canada. The most recent forecast of future paper and board consumption in the United States was that made by the U. S. Forest Service in 1952 as part of a comprehensive study of the over-all resources of the United States,[§] and it is these figures which have been used as the basis for the estimates contained in this survey. This forecast related to the year 1975, starting from 1950 as base year; the salient figures given in this report are quoted in Table XIX.

§ Report of the President's Materials Policy Commission (the Paley Report).

Table XIX. Appraisal of 1975 Requirements for Paper and Board in the United States

Million metric tons

Category	1950 consumption	1975 requirements	Increase, 1950 to 1975 — Total	Increase, 1950 to 1975 — Percentage increase Total %	Increase, 1950 to 1975 — Percentage increase Yearly, %
Newsprint	5.2	7.9	2.7	52	1.7
All other paper	10.0	18.2	8.2	64	2.0
Paperboard	11.1	20.9	9.8	88	2.6
Total	26.3	47.0	20.7	79	2.4

This forecast is based on the assumption that gross national product will rise by 100% between 1950 and 1975, i.e., by 2.8% annually. Thus paper consumption is reckoned to rise somewhat more slowly than national income, a consequence of the very high consumption per head already achieved. Newsprint is expected to show the slowest rate of increase, while the rise in board consumption is expected to come closest to the rise in national income.

With an assumed population in the United States by 1975 of 193 million people, as against 152 million in 1950, the forecast corresponds to a per capita consumption in 1975 of 242 kg. of paper and board, including 41 kg. newsprint, as against 173 and 35 kg., respectively in 1950. It implies that, of the total increase by 1975, roughly half would follow from the increase in population and half from increased per capita consumption.

On an arithmetic basis, the annual increase of 830,000 metric tons a year is slightly greater than that which occurred between 1929 and 1951, between which two peak years consumption rose from 12.2 to 27.8 million metric tons, i.e., by 710,000 tons annually. Most of the increase during this period, however, took place in the last 15 years. From 1937, also a peak year, to 1951 consumption rose from 14.6 to 27.8 million metric tons, an increase of 940,000 tons a year, considerably less than the annual increase forecast from 1950 to 1975. It has been assumed that the arithmetical rate of increase reckoned for 1950 to 1975 will be maintained through the first decade; the interpolated forecast has been taken as applying to average consumption in the period 1960–62.

Canada today ranks next to the United States in terms of per capita consumption, with 118 kg. per head in 1950. Moreover, both population and per capita consumption are rising even faster than in the United States. It is estimated that total consumption will by 1960–62 rise to 2.18 million tons as against 1.62 million in 1950. This would give, for the region as a whole, a rise of 29% by 1960–62 as compared with 1950–52.

Corresponding wood pulp requirements would rise from 21.4 to 27.0 million metric tons, or, if we make an allowance for dissolving pulp requirements from 22.1 to 28.1 million metric tons. Pulpwood requirements would rise from about 93 million cubic meters to about 112 million cubic meters. Both of these estimates relate only to needs for the region's own consumption of paper, board, and dissolving pulp; neither includes any allowance for net exports overseas.

It is not assumed that there will be any improvement in the pulp to paper ratio, other than that occasioned by the changing pattern of consumption of paper products. It is assumed, however, that pulpwood savings will be made, both as a result

Table XX. Estimated Rise in North American Paper and Board Consumption, 1950–52 to 1960–62

Million metric tons

	Newsprint	Other paper	Board	Total
1950–52	5.7	10.8	12.0	28.6
1960–62	6.8	14.0	16.1	36.8
Percentage rise	18	30	34	29

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Table XXI. Forest Area in North America

Country	Total forested area, thousand hectares	Accessible productive forests — Total, thousand hectares	Accessible productive forests — Per head, hectares	Accessible productive forests — Conifers, %
USA	314,453	182,115	1.2	56
(of which Alaska)	(61,920)	(11,332)	(80.9)	(76)
Canada[a]	341,963	130,168	9.0	72
Total: North America	656,416	312,283[b]	1.8	63

[a] Excluding Labrador.
[b] Includes more than 50 million hectares of productive forests not yet exploited.

of technical improvements and as a result of using a bigger proportion of high yield pulps.

Average pulpwood consumption of North American mills in 1950–52 was about 37.5 million cords, or 96 million cubic meters, of which 66 millions were consumed in the United States. Of this total, about 2,250,000 cords (6 million cubic meters) were imported from Canada—a further element in the pattern of United States dependence on Canada's forest resources mentioned earlier.

What are the prospects of obtaining from the North American forests the additional pulpwood that will be necessary to satisfy increasing pulp products requirements? A survey of the region's forest resources shows that the region is well provided with forests. The accessible forest area in the United States and Canada, and its distribution between conifers and broad leaved species, is given in Table XXI.

Reckoning only the accessible area of the productive forests, 312 million hectares, this corresponds to 1.8 hectares per inhabitant, compared with 0.3 hectare in Europe. To this should be added the potential reserves invested in the 150 or so million hectares, mainly in Canada and Alaska, today classified as inaccessible but productive.‖ At the same time it has to be noted that the consumption of wood products, per head as well as in total, is much higher than in Europe.

A corollary of this high level of wood consumption has been in the past an unwise exploitation of the seemingly inexhaustible forest resources. Although a new forest generation, partly man-made has largely replaced the virgin forests on the cut-over lands, it is still considered that the productive capacity of the forest land today is by no means fully utilized. This, of course, leaves a big margin for raising forest production, but it is not a margin which can be readily realized.

In the United States, according to the Paley Report, drain and growth just about balance each other at the present time (370 to 400 million cubic meters). But within this over-all balance serious overcutting of saw timber takes place, while the drain in softwoods exceeds growth. However, growth is increasing, and is expected to keep pace with rising requirements after making allowance for increased imports (especially of newsprint) from Canada. A forecast for 1975 (assuming that the rate of losses from fire, insects, disease, storms, etc., can be halved) is presented in Table XXII:

‖ The remaining 200 million hectares of forest are described as unproductive forests. They include such forests lying within accessible areas.

Table XXII. United States Growth and Requirements in 1975

Million cubic meters with bark

	All timber	Of which: saw timber
Requirements of domestic commodity use	416	152
Losses	23	4
Margin for security and export	71	14
Total	510	170
Prospective growth 1975	450–480	99

Should this prediction prove accurate, difficulties may be experienced in maintaining the output of saw timber, while the prospects for industries based on small-dimensioned wood (notably the pulp and paper industry) will be somewhat brighter, especially so as it may confidently be expected that increasing quantities of nonconifers will be pulped.

This forecast, as may be seen, leaves little margin for contingencies. On the other hand, it does not take into account the forest resources of Alaska, capable of producing about 1 million tons of newsprint in perpetuity and only now being taken into productive use. Nor does it reckon with the possibilities of using vastly increased quantities of waste from the sawmills and other wood-using industries as raw material for the pulp mills. The sawmill waste alone from the 15 million standards of softwood cut in the United States could, if utilized on the same scale as now in Scandinavia, provide an additional 7 million cubic meters of pulpwood.

As for Canada, the potential supply of pulpwood has not been fully ascertained. Of the total forested area of 342 million hectares, 130 million are today classified as accessible productive forests; nearly half of these, 64 million hectares, are as yet unexploited. Growing stock in the accessible productive forests is estimated as shown in Table XXIII.

Table XXIII. Standing Stock in Canada's Accessible Productive Forests, 1953

Million cubic meters with bark

	Saw timber, 25 cm d.b.h. and up	Smaller material, over 10 cm. d.b.h.	Total
Softwood	3650	2000	5650
Hardwood	1320	290	1610
Total	4970	2290	7260

This indicates an adequate supply of standing timber in relation to annual removals (around 90 million cubic meters). Total drain, however, is considerably higher, since losses from fire, insects, disease, etc., are estimated at roughly 21 million cubic meters a year. No annual increment figures are available, but annual growth is believed to be low, perhaps as low as 0.8 cubic meters per hectare. This would give, for the accessible productive forests only, a total annual growth of about 110 million cubic meters.

These bare and approximate figures might suggest an uneasy balance between growth and drain. That, however, would be quite a wrong picture. A determined attack on losses could raise output considerably; it has been estimated that forest fires alone destroy about a quarter as much timber each year as is used by the pulp and paper industry. There are considerable opportunities for improving upon the present low figure of growth. And finally some of the 211 million hectares of forest today classed as inaccessible will undoubtedly be exploited in due course. It has been estimated that the Canadian forests, if well managed and fully developed, could sustain in perpetuity an output of forest products of approximately twice the present volume.

To summarize: North America as a whole, according to all the evidence available, has an ample supply of wood for pulp and papermaking in the short and medium term. In the case of the United States however, this would presume an increased use of nonconifers and of wood waste, both of which occur in large quantities readily available. In the long term, the possibilities for a substantial increase in pulp and paper output will depend upon growth in the forests and on the reduction of losses. In view of the great margin available for improvement in both these respects it seems reasonable to expect that raw materials will not present any obstacle to an expansion of the pulp and paper industry fully capable of meeting future requirements at the levels we have estimated.

Resources for further expansion are then not lacking. Will

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the capacity to utilize those resources develop sufficiently rapidly to meet rising requirements?

The dynamic nature of the North American pulp and paper industry is well demonstrated by the remarkable increase that took place after the war. At the end of 1945, United States pulp capacity stood at 10.9 million metric tons; by the end of 1950 it had risen to 14.6 and at the end of 1953 stood at 17.9 million metric tons. Over the 8 years the annual increase averaged 900,000 metric tons. It has been estimated that from 1945 to 1952 the United States pulp and paper industry spent more than $3000 million on plant and equipment and a further expenditure of $400 million was scheduled for 1953. Moreover, it has been calculated that if all projects so far announced are completed, capacity will rise to 20.3 million metric tons by the end of 1955, implying that the recent rate of expansion will be more than maintained in the next 2 years.

Exactly comparable figures for Canada are not available, but capacity in 1950 stood at 8.2 million metric tons; pulp production in that year was 7.7 million tons, an increase of 2.6 million tons over 1945. By the beginning of 1955 capacity is expected to rise to 9.5 million tons.

We have estimated that between 1950–52 and 1960–62 North American pulp needs will rise by 6 million metric tons. Between the end of 1951 and the end of 1955, if all present plans are completed, about 5.5 million metric tons will have been added to North American pulping capacity. Even allowing for the fact that capacity is not utilized 100%, and that the ratio of utilization in 1951 was exceptionally high, it is clear that capacity is increasing at a rate faster than that at which demand for pulp is expected to increase.

Many of the new projects were conceived under the incentives of boom years and easy money; all have been decided upon against the background of the long-term upwards trend in North American consumption. Some of the plans announced may not materialize, while others will be slowed down. Nevertheless it is difficult to escape the conclusion that the American industry is in danger of becoming overexpanded in relation to the level of domestic demand; indeed that situation has perhaps already been reached. If this is so, we may expect North American producers, and especially manufacturers of paper and of market pulp, to display much more interest in overseas markets than they have done hitherto, when every effort was needed to satisfy booming domestic demand.

There is therefore a real possibility that, at any rate for the next few years, the surplus of pulp and paper available in North America for export to other regions may be substantially greater than at any time in the past. It would, however, be incautious to assume that this surplus will endure and become a permanent feature of international trade in pulp and paper.

If it were only a matter of raw material resources and industrial capacity, there would be no difficulty in producing substantial quantities of pulp and paper in North America for export—and on a profitable basis. The region's transformation in recent years from a pulp and paper deficit area to an "in balance" area would seem to argue in favor of such a development. There are, however, other factors to be taken into consideration. First and foremost we have to reckon with the well-nigh universal shortage of dollars. This problem is not likely to vanish in the next few years. So long as it remains, it will be a standing inducement to the rest of the world to make every effort to satisfy its own pulp and paper needs, and to conserve its precious dollar earnings for more vital needs. Moreover, so long as the problem remains, the overseas countries will not afford dependable markets for North American producers. Though this will not prevent those producers from taking advantage of overseas markets when domestic demand fails to effectively employ capacity, it will inhibit them from making substantial investments aimed primarily at producing for export overseas.

One possible exception to this general appraisal should be mentioned. There has been a traditional flow of forest products, mainly sawnwood, but also newsprint and other forest product categories, from North America to Western Europe, and especially to the United Kingdom. Since the war the volume of this trade has fluctuated in sympathy with changes in payments balances. While Western European countries will continue to look primarily to their northern neighbors for most of their needs, they may be expected to supplement those supplies by imports from North America in the measure in which their economic position allows them to do so. This is perhaps especially the case for newsprint since, as we have seen, it is unlikely that newsprint capacity in Europe will increase sufficiently to allow, for example, United Kingdom consumption, to be restored to its prewar level in the next decade.

Summarizing our conclusions, we have to acknowledge the existence of reservations as to the part which North America can play in meeting the increasing deficits in the less developed regions in the long term. These reservations do not spring from any fear that production in that continent is not capable of a considerable further expansion. We have seen how rapidly United States pulping capacity has adjusted itself to the phenomenal rise in demand in recent years. Canadian newsprint output, which has stepped up sharply since the war as much by machine improvements as by the creation of additional capacity, has by no means exhausted its possibilities of growth; given any measure of restoration of multilateral trading, there could be a substantial production developed in Canada for overseas export. The reservations flow in part from the marginal, and hence uncertain, nature of the North American surplus (because of the exceptionally high level of production and consumption in that region) and, more particularly, from the problems of payment involved. Dollar scarcity today inhibits deficit countries from placing overmuch reliance on imports from North America, especially when other commodities present competing claims in dollar import programs. Conversely, overseas markets which are subject to interruption through dollar scarcity afford no strong attraction for North American producers in normal times. For this reason, if no other, it would be unrealistic to look for an expansion in North American output capable of permanently satisfying the ever-increasing import needs of other regions.

Thus, while an exportable surplus of paper may remain and amounts of pulp be available for export from time to time, there is not likely to be a steady and growing excess of production over the continent's own needs in the long term.

USSR

The Soviet Union possesses the largest area of coniferous forest in the world. According to the statement of Deputy Minister for Forestry, Mr. Kaldanov, the USSR State forest reserves (including collective farm forests) covered 1069 million hectares in 1950: 743 million hectares, or 69% of the total area, was timbered. This corresponds to a forest area per inhabitant of 3.8 hectares, roughly ten times that in Europe. Conifers cover 492 million hectares or 66% of the timbered area.

Nevertheless paper and board consumption is low by western standards. In 1950–52 it averaged only 9.5 kg. per head, as against 30 in Europe and 170 in North America.

It is estimated that in 1937 the Soviet Union produced about 1.1 million tons of paper and board, including approximately 190,000 tons of newsprint. By 1950, production had risen to 1.7 million tons, including 360,000 tons of newsprint. Subsequent plan fulfillment figures indicate a fairly rapid increase in production, which should, if the targets in the current Five Year Plan are achieved, rise to 2.5 million tons by 1955. Average consumption during the years 1950–52 is estimated at 1.92 million tons, of which newsprint accounted for about 400,000 tons.

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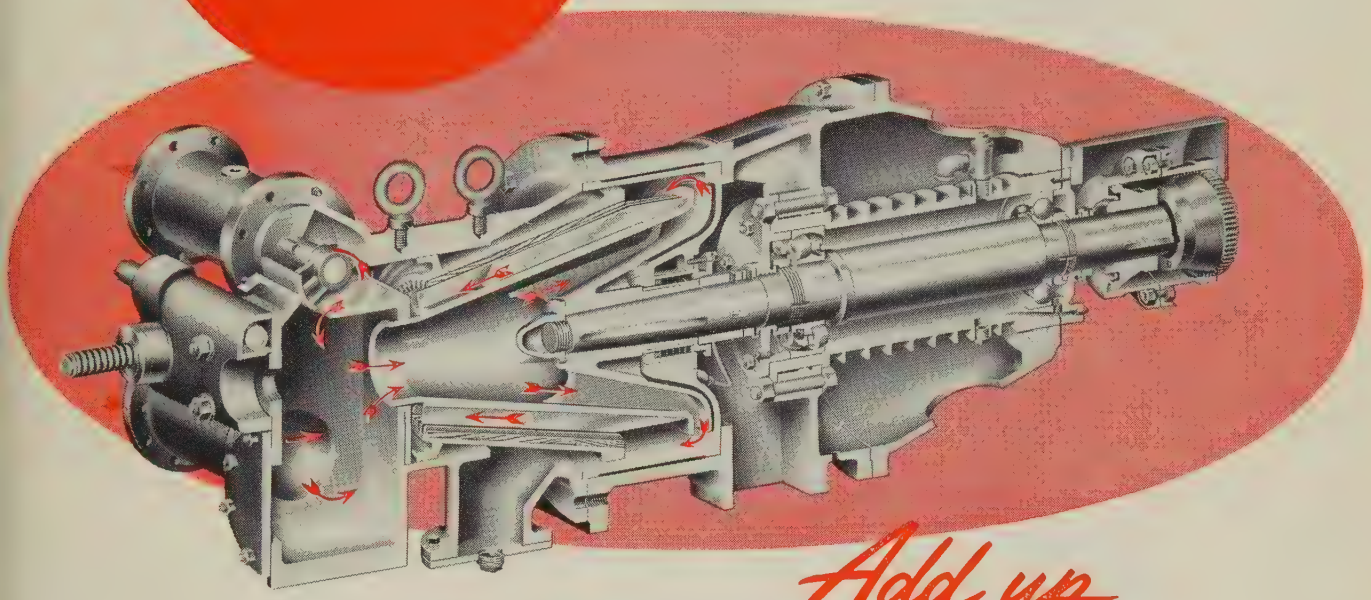

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The rise in consumption which has taken place since the war has occurred in spite of the emphasis given, in the country's general economic development, first, to repairing the ravages of war, and, second, to securing the heavy industry basis for subsequent development. Consumption of pulp products is limited only by the supplies available; it should be pointed out, therefore, that the level of consumption estimated for 1960–62 in this survey, 3.0 million tons annually (including 700,000 tons of newsprint) could well prove to be on the low side. The shifts which are now taking place in the Soviet economy, not only in the direction of increasing the flow of consumption goods, but also in increasing consumer satisfactions (involving, for example, higher standards of packaging), could imply an even more rapid rise in consumption. Certainly the Soviet Union has a long way to go before it reaches even Western European standards of consumption. For example, though daily newspaper circulation is reported to have risen from 31.0 million in 1949 to 41.7 million in 1953, even the latter figure implies only a daily circulation of 198 newspapers per thousand inhabitants. The most recent corresponding figure available for the United Kingdom (1952) is 611; for France, Italy, and Sweden the figures are 239, 107, and 490, respectively.

How far consumption actually rises will thus depend on the share which the Soviet authorities accord to pulp and paper developments in the total investment program and on the degree to which they are prepared to supplement domestic supplies by imports. Clearly, given a substantial expansion in her pulp and paper industry, the USSR could become an exporter of first-rate importance. Her total standing timber reserve is estimated at 59,000 million cubic meters, of which about 85% is predominantly coniferous. Tremendous strides in assessing the forest reserves and bringing the forest areas under proper forest management have been made since the former Central Forest Conservancy Board was superseded by a Ministry of Forestry in 1947. The center of gravity of exploitation has steadily shifted from the depleted stands and underforested areas of the Northwestern, Western, and Southern parts of European Russia, from the Central Provinces, the Volga region, etc., to Northern European Russia, the Urals, and Eastern and Western Siberia. Under the Stalin "Plan to Transform Nature" considerable progress has been made in protective afforestation, including major state shelter belts, field protection shelter belts, and steppe afforestation. This struggle against aridity aims at preventing the encroachment of the Middle Asia desert climate into the fertile Russian plains. Setbacks have been encountered, notably in securing a high rate of survival in the new sowings and, in the sphere of management, in insuring that collective farm forests are exploited on sound lines.

Recently there have been indications that "giant projects" have tended to swallow up too big a proportion of the Soviet Union's total resources, at the expense of postponing some of the looked-for improvement in the flow of consumer goods. Some tapering off of earlier afforestation plans would be consistent with other changes which have taken place in internal Soviet policy. The steady process of bringing existing forests under rational management, however, is likely to continue.

These advances in forestry management have been accompanied by progress in the timber industry. In 1950, fellings amounted to 300 million cubic meters; by 1955 the annual cut is expected to rise to 370 million cubic meters. The pulp industry's share in the total cut, however, is small. Pulpwood production in 1950 was 7.5 million cubic meters; by 1953, it had risen to 9.5 million and was planned to reach 10.5 million in 1954. It is expected that these supplies will continue to be supplemented by pulpwood imports from Finland at the current rate of 300,000 cubic meters annually.

With the rehabilitation of the timber industry and the satisfaction of the most pressing reconstruction needs, the traditional export trade in sawnwood is gradually being resumed. In 1953, the USSR exported about 250.000 standards of sawn softwood to Western Europe, and this figure will probably rise to between 300,000 and 400,000 standards in 1954 if trade conditions continue favorable. It is noteworthy that today a bigger proportion of Soviet exports emanate from the Arctic ports of Igarka, Mezen, and Naryan-Mar than before the war. As yet, however, there has been no sign of any readiness to export any substantial quantities of pulpwood; before the war about 3 million cubic meters of pulpwood were exported annually by the Soviet Union. The indications are that this trade is unlikely to be resumed in any volume for some considerable time, if at all.

From the point of view of resources, the possibilities of the Soviet Union ultimately becoming a supplier of pulp and paper to the less well-endowed regions of the world are almost limitless. The prospects of her fulfilling this role in the next 10 to 15 years, however, seem to be remote. The current Five-Year Plan (1951–55) gives no special emphasis to the development of the pulp and paper industry, and the expansion contemplated would seem no greater than will be required to satisfy rising domestic needs. Indeed, it is more likely that rising standards of consumption will prompt her to call increasingly on the European surplus to supplement her own production. In 1953, the Soviet Union imported 28,000 tons of wood pulp and 54,000 tons of paper and board from Finland, against 12,000 and 30,000 tons, respectively, during 1952. In a recently signed trade agreement with Sweden, 10,000 tons of paper appear as a new item.

On the evidence available, therefore, our conclusion must be that, great as are the USSR's potentialities, there is little likelihood of her becoming an important exporter of pulp and paper to the deficit regions of the world in the next decade.

Latin America

Rapidly growing population, a high rate of economic growth and sharply rising paper consumption characterize the Latin American region. The rate of growth of population, 1.9% annually, is one of the highest in the world. In recent years national income per head has been rising by between 2.5 and 3% annually. The rate of literacy, though it differs considerably from country to country, is rapidly rising and for the region as a whole is today around 45 to 55%.

The following summary of the situation in Latin America is based mainly on information and data presented in the Joint ECLA/FAO Study of the region¶ and on reports of FAO Survey Missions which have visited the following countries: Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Haiti, Mexico, Paraguay, Peru, and Venezuela. The facts and figures contained in these reports have been supplemented by information which has more recently become available.

The present (1950-52) consumption of paper products in Latin America is estimated at about 1,450,000 tons a year, of which about 415,000 tons is newsprint. The main consuming countries are Argentina (425,000 tons), Brazil (350,000 tons), Mexico (215,000 tons), and Cuba (120,000 tons); these four countries between them account for three-quarters of the region's total consumption.

For the region as a whole, consumption per head is 8.8

¶ Preliminary Study of the Possibilities for the Development of the Pulp and Paper Industry in Latin America (ECLA/FAO 15/7/1953).

Table XXIV. Estimated Future Demand for Paper Products in Latin America

Million metric tons

Year	*Newsprint*	*Other paper and board*	*Total*
1950	0.39	0.97	1.36
1950–52	0.42	1.03	1.45
1955	0.53	1.27	1.80
1960	0.72	1.82	2.54

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Table XXV. Production Capacity and Actual Production of Paper Products in Latin America, 1950

Thousand tons per annum

	Production capacity			Actual production				
	Newsprint	*Other paper and board*	*Total*	*Newsprint*	*Writing and printing*	*Other paper*	*Board*	*Total*
Argentina	..	250	250	..	43	104	64	211
Bolivia	..	..	0.5	..	..	..	..	0.5
Brazil[a]	38	230	268	38	66	121	23	248
Cuba	..	55	55	..	..	21	13	34
Chile	12	51	63	11	10	18	4	43
Ecuador	..	..	0.6	..	..	..	..	0.6
Mexico	4	240	244	4	34	50	44	132
Peru	..	25	25	..	2	9	6	17
Uruguay	..	38	38	..	..	20	10	30
Venezuela	..	8	8	..	..	5	3	8
Total	54	897	951	53	155	348	168	724

[a] Production capacity and actual production may be some 30,000 tons higher, as a number of small boardmills are not included in the statistics.

kg.; it ranges from 24 kg. in Argentina and 22 in Cuba, down to around 500 grams in Haiti. Only in Argentina, Cuba, and Uruguay does consumption per head come anywhere near the European average. Elsewhere in the region, even in Brazil. Chile, and Mexico, it falls well below.

Because of the expected rapid development of the region (3% annual increase of per capita income) and the high rate of population growth, demand for paper products is likely to rise more rapidly than in most other regions. It is thus estimated that demand will rise by 1,090,000 tons to 2,540,000 tons in 1960, of which 720,000 tons would be for newsprint.

These estimates rest on the assumption that demand will not be depressed by abnormal factors such as high import duties, lack of foreign exchange, high prices, and undue restrictions on paper usage. Consumption in 1950–52 was met partly by import—about 640,000 tons, of which 355,000 tons were newsprint—partly by local production—about 810,000 tons, of which only 60,000 tons were newsprint.

It is convenient to take the year 1950 as the base year for discussing present and future developments; in that year local production amounted to about 725,000 tons, of which 53,000 tons were newsprint. But the rated production capacity of the paper industry in 1950 was considerably higher, about 950,000 tons. The main production capacities are located in Argentina, Brazil, and Mexico, which together accounted for 760,000 tons, over three quarters of the regional total.

Table XXV shows the installed capacity and the actual production of various paper products in the region in 1950.

The largest difference between installed capacity and actual production is noted for Mexico (110,000 tons) where the industry worked at only 55% of capacity. For the purpose of this report it is assumed that regional production capacity could be utilized at 100% in the case of newsprint and 90% for other paper and board. Actual production capacity is thus estimated at 54,000 tons for newsprint and 810,000 tons for other categories. It should, however, be kept in mind that this estimate may be on the high side as most of the mills produce a wide range of products, which results in frequent change-overs and loss in capacity. In addition, some of the integrated mills located far from the forest resources—especially in Mexico—are often affected by temporary shortages of pulpwood which, in turn, prevent the full use of their capacity.

A number of projects for expanding the capacity of existing mills as well as for establishing new industries are at present under way in Latin America. Some have already been completed, others are under construction and still others exist only as blueprint schemes. In Table XXVIII an attempt has been made to list those projects which have been or are likely to be carried out within the period of forecast. The table should be interpreted with caution as it was not possible to obtain detailed information about all the projects in countries not surveyed by FAO missions. Some projects may have been omitted, while others, included in the table, may prove impracticable after more detailed investigation.

If all the projects listed are carried out, regional production capacity will rise to 280,000 tons per year for newsprint and about 1,135,000 tons for other paper and board. A comparison between estimated future demand and the prospective supply, assuming that imports could be maintained at the 1950–52 level, shows that, unless further expansions are projected and completed, Latin America will by 1960 have an increase in its annual deficit of about 85,000 tons of newsprint and 400,000 tons of other paper and board. It would thus seem that if paper consumption in Latin America is to rise at a rate consonant with the expected economic growth, then either the region will be required to import by 1960 from Europe and North America well over 1.1 million tons annually (as compared with 640,000 tons in 1950–52) or paper capacity within the region must expand by some 70,000 tons a year over and above present plans.

The existing paper industry in the region consumes yearly 452,000 tons of chemical pulp (not including 35,000 tons of dissolving pulp for other purposes) and 142,000 tons of mechanical pulp. Of these quantities about 267,000 tons of chemical and 24,000 tons of mechanical pulp are imported, mainly from the Scandinavian countries.

As shown in Table XXVI, the estimated future annual requirements of chemical and mechanical pulp, over and above present imports, for a regional production of paper sufficient to meet the supply deficit, will amount to 665,000 tons and 510,000 tons by the year 1960.** An additional amount of papermaking fibers from waste paper and rags of 370,000 tons is required.

The pulp mills (integrated and nonintegrated) in the region had a total rated production capacity of 238,000 tons of chemical and 218,000 tons of mechanical pulp per annum; actual production in 1950 was 185,000 and 118,000 tons respectively.

The large discrepancy between rated capacity and actual production for mechanical pulp is due to a local over-capacity of about 100,000 tons, mainly in Brazil and Mexico. These

Table XXVI. The Regional Paper Industry's Consumption and Requirements of Domestic Pulp

Thousand metric tons per annum

Year	*Mechanical pulp*	*Chemical pulp*	*Other fibers*	*Total*
1950	118	185	176	479
1960	515	690	380	1585

Note: In 1950, actual consumption. In 1960, assuming imports at the present level.

** Pulp requirements are calculated from estimated future paper consumption after deducting present imports of paper and pulp. For converting paper into pulp equivalents, the following factors were used, which were computed from actual consumption figures for the three-year period 1950–52:
Mechanical pulp: newsprint × 0.92; other papers and boards 0.125.
Chemical pulp: newsprint × 0.13; other papers and board × 0.62.
Other fibers: other papers and boards × 0.26.

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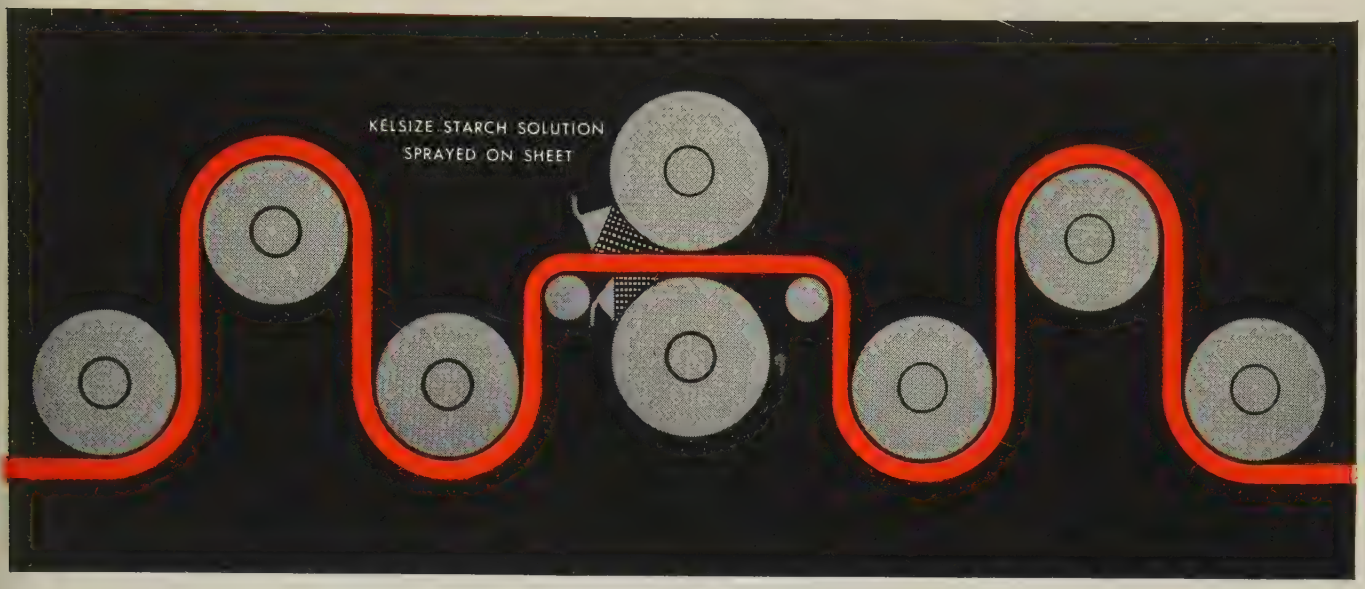

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Table XXVII. Production Capacity and Actual Production of Pulp in Latin America, 1950

Thousand metric tons per annum

	Rated production capacity			Actual production		
	Mechanical	Chemical	Total	Mechanical	Chemical	Total
Argentina	7	43	50	7	34	41
Brazil	125	74	199	80	74	154
Chile	23	6	29	16	5	21
Mexico	63	93	156	15	50	65
Peru	..	13	13	..	13	13
Uruguay	..	9	9	..	9	9
Total	218	238	456	118	185	303

mills, because of their small and uneconomic size and because of the difficulties they have in obtaining a continuous supply of pulpwood, are probably not in a position to compete on the market during times of normal price level. In the case of chemical pulp the main discrepancy is noted for Mexico, where apparently the same conditions exist as for the mechanical pulp mills.

For the purpose of this report it is therefore assumed that actual production capacity in 1950 was 120,000 tons for mechanical and 200,000 tons for chemical pulp.

Many projects for expanding the pulp industry are under study at the present time. They are listed in Table XXVIII along with the paper mill projects and the same note of caution should be observed as for the latter.

If all the projects listed are carried to completion, regional production capacity will reach, by 1960, 648,000 tons of chemical and 304,000 tons of mechanical pulp. It will be seen that the expected increase in chemical pulp capacity comes fairly close to meeting the estimated additional needs, whereas the present deficit of 24,000 tons in mechanical pulp would rise to over 200,000 tons; both these estimates, it should be emphasized, presuppose that the continent will continue to import pulp and paper from other regions in the same quantities as at present.

Thus if demand at the estimated level is to be satisfied without imports from other regions exceeding the 1950–52 rate, Latin America will be required to add by 1960 the following mill capacity, including the present plans for expansion:

	Additional capacity required, thousand metric tons	Additional capacity projected, thousand metric tons
Newsprint	305	225
Other paper and board	725	325
Mechanical pulp	395	185
Chemical[a] pulp	505	450

[a] These figures do not take into account additional requirements, and plans for increasing capacity, of dissolving pulp. It is estimated that requirement of dissolving pulp will rise by 45,000 tons; 50,000 tons of new capacity are projected.

To achieve the required additional capacity, over 30 integrated pulp and paper mills of 30,000 tons annual capacity would have to be projected and constructed during the period 1950–60. Save for chemical pulp, the additional capacity so far projected falls considerably short of that required. Moreover, of the additional capacity projected, only 12% of that for paper and mechanical pulp and about 25% of that for chemical pulp was actually built or under construction at the end of 1953.

Table XXVIII. List of Pulp and Paper Mills Under Construction or Likely to Be Constructed in Latin America During the Current Decade

Thousand metric tons per annum

		Capacity							
Country	Site	Newsprint	Other papers and boards	Mechanical pulp	Chemical pulp	Dissolving pulp	Process[a]	Raw material	Remarks
Argentina	Zarate	50	...	44	...	..	1	Salicaceous species	20,000 tons constructed
Argentina	Puerto Piray	...	...	...	30	..	2	*Pinus radiata* (?)	Under construction
Argentina	Others	...	120	...	60	9	...	.....	Argentine 5-year plan
Brazil	São Paulo	...	11	...	7	..	...	Bagasse	.....
Brazil	São Paulo	...	6	...	...	..	...	.....	Extensions
Brazil	Paraná	...	22	...	...	..	...	.....	Extensions
Brazil	São Paulo	...	...	...	114	..	...	Eucalyptus	Three projects
Brazil	São Paulo	97	...	...	...	..	...	.....	Two projects
Brazil	Paraná	...	...	...	27	..	...	Mixed woods (?)	.....
Brazil	São Paulo	...	...	...	...	15	...	Eucalpytus	.....
Chile	Valdivia	...	5	...	...	..	...	.....	Already built
Chile	Concepción	44	11	40	50	6	1 + 2	*Pinus radiata*	.....
Colombia	Cali	...	24	...	10	..	(?)	Imported pulp and bagasse	Already built
Colombia	Cali	...	12	...	...	..	...	Imported pulp and bagasse	Extension
Colombia	Puerto Boyacá	20	...	20	...	..	...	Mixed tropical woods	.....
Costa Rica	Pacuare river	...	3	...	3	..	3	Abacá fibers	Already built
Cuba	Not given	...	20	...	15	..	(?)	Bagasse	.....
Dominican Republic	Rio Haina	...	10	...	7	..	5	Bagasse	.....
Ecuador	Latacunga	...	3	...	3	..	...	Agriculture residues	Already built
Mexico	Chihuahua	...	...	...	26	20	2	Conifers	Under construction
Mexico	Chihuahua	(?)	...	10	...	..	1	Conifers	.....
Mexico	Durango	...	...	60	...	..	1	Conifers	.....
Mexico	Michoacan	...	...	...	30	..	4	Conifers	.....
Mexico	Yucatan	...	30	...	30	..	4	Mixed tropical woods	.....
Mexico	Ayotla	...	...	...	9	..	(?)	Bagasse	Machinery purchased
Mexico	Monterrey	...	12	...	...	..	...	(?)	Already in operation
Mexico	Mexico	...	...	...	12	..	4	Wood (conifers (?))	Extension project
Mexico	Mexico City	...	22	...	...	..	...	Waste paper and wood pulp	Three projects, already in operation
Peru	Pucallpa	15	3	10	5	..	1 + 4	*Cecropia sp.*	(Ev. cold caustic soda process)
Venezuela	Lake Valencia	...	12	...	10	..	5	Bagasse	(Ev. mechano-chemical process)
Total Latin America		226	326	184	448	50			

[a] (1) Mechanical process; (2) sulphite process; (3) soda process; (4) sulphate process; (5) caustic soda-chlorine process; (6) mechano-chemical process; and (7) semichemical process.

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The total development program would require an investment of about $350 to $400 million. It seems unlikely that Latin America could finance by itself such a program of expansion. The supply of domestic investment capital is limited, and there are many competing claims on that supply. The extent to which a program on this scale can be achieved therefore depends on the degree to which foreign capital, allied to industrial experience and technical skills, can be attracted.

Given pulp and paper imports at the present rate, the Latin American pulp industry, in order to satisfy expected requirements, would have to produce, by 1960, approximately 500,000 tons of mechanical pulp and 700,000 tons of chemical pulp. The yearly requirements of fibrous raw material may be roughly estimated at 2.5 million tons of wood or other suitable raw material.

The continent's accessible fibrous resources far exceed these calculated requirements and are capable of supporting any foreseeable future expansion.

Four main groups of raw materials are found in the region:

1. Tropical mixed broadleaved forests;
2. Conifers from natural forests and plantations;
3. Nonconiferous plantations, mainly eucalyptus and species of the family salicaceae;
4. Agricultural and industrial residues, mainly wheat straw and sugarcane bagasse.

By far the most important of the continent's resources are the broadleaved species from mixed tropical forests, principally those of the Amazon basin. However, the lack of economic development in the most richly forested tropical areas, as well as the problems, mainly economic but some technical, involved in pulping mixed hardwoods, make it unlikely that these areas will compete in the immediate future with more accessible coniferous zones which are close to markets and which provide woods that can easily be treated with familiar industrial processes. In the longer term, however, the tropical resources will become extremely important as pulping materials, not only because of their great abundance, but also because of the possibilities offered of integrating pulp and paper manufacture with other wood industries, as distinct from the irrational exploitation of these forests for timber extraction which is general today. If the long-term significance of tropical woods has been emphasized, this is not to say that the problem of utilizing them can today be shelved and efforts concentrated on exploiting the coniferous resources. On the contrary, economic studies and pulping tests of tropical woods need to be initiated now if conclusions sufficiently definite to serve as a basis for industrial projects are to be reached in the next few years. The possibility of installing one or more plants to provide the necessary industrial experience should be closely investigated forthwith.

There are sound reasons why this exploratory phase should not be delayed. As will be seen later, the region's coniferous resources, though ample for present needs, will not be equal to satisfying the demand which is likely to arise in two or three decades' time. Since long-fibered coniferous pulp cannot be economically replaced by other fibers in the manufacture of newsprint and kraft paper, it would be wiser, taking the long view, to conserve the region's coniferous resources for these end-uses and to develop other resources capable of satisfying the less exacting requirements of other paper categories.

Table XXIX. Estimated Sustained Annual Yield of Pulpwood from Main Coniferous Resources of Latin America by 1965

Thousand metric tons of air-dry material

Country	*Zone*	*Species*	*Annual yield pulpwood*
Chile	Concepción	*Pinus radiata*	2000
Brazil	Paraná	*Araucaria angustifolia*	700
	Sta. Caratina	*Araucaria angustifolia*	300
	Rio Grande do Sul	*Araucaria angustifolia*	150
Mexico	Chihuahua	*Pinus spp.*	160
	Durango	*Pinus spp.*	125
	Michoacan	*Pinus spp. Abies spp.*	120
	Guerrero	*Pinus spp. Abies spp.*	200
Argentina	Misiones	*Araucaria angustifolis*	80
Total			3835

The most important coniferous resources are found in Chile, Brazil, and Mexico. Table XXIX gives an estimate of the sustained annual yield from these resources.

These figures relate only to certain selected areas, considered most suitable for the development of a pulp and paper industry. Other large coniferous resources are found in Mexico, Central America, and the Caribbean.

The estimated annual yield of 3.8 million tons is more than sufficient to cover the entire requirements (2.5 million tons) of fibrous raw material for pulp within the period considered in the present report. But requirements of fibrous material will continue to rise in ensuing decades. This is why the coniferous resources should be, to a certain extent, kept as a reserve for long-term future requirements of categories of paper requiring long-fiber pulp.

The Insignis pine plantations in Chile offer outstanding possibilities of immediate development, as shown by the following quotation from the ECLA/FAO report:

"It may be stated that the Insignis pine plantations constitute one of the best sources of pulp in Latin America. The accessibility of the plantations, the rapid growth and their facility for regeneration provide a series of factors difficult to equal in any other Latin-American country. The large stands already accumulated demonstrate the urgent need to organize a new use for these resources, apart from the present use as sawn timber."

Of the nonconifer plantations, the main resources are the eucalyptus plantations in Brazil. For short-term development, the three zones referred to as "Rio Claro," "Vale do Paraiba," and "Zone Norte," all in the State of São Paulo, are considered most suitable. These plantations could give an estimated annual yield of 450,000 to 500,000 tons of pulpwood, equivalent to some 200,000 tons of chemical pulp.

Another important plantation area is in the Paraná delta where about 60,000 hectares of species of the family salicaceae (willow, poplar, etc.) are planted. The estimated annual yield of about 550,000 tons of wood is at present almost entirely used for box manufacture. Further afforestation in this area could ultimately satisfy Argentina's mechanical pulp needs.

Two important nonwood resources are found in the region—wheat straw and sugarcane bagasse. Pulps made from them can be used for a wide variety of papers. Their main uses are in producing high grade writing and printing papers, greaseproof and glassine papers and boards, either alone or in blends with coniferous pulp; in the latter case they give improved sheet formation, surface characteristics and printability.

However, only those quantities of straw surplus to agricultural requirements can be taken into account as raw material for pulp, while the pulping of additional quantities of sugarcane bagasse depends on alternative fuels being available to the sugar mills at reasonable cost.

The main potential straw supply area is Argentina, where the four provinces of Buenos Aires, Cordoba, Entre Rios, and Santa Fé alone could furnish annually 1.8 million tons of straw (30% of the recoverable straw).

Considerable quantities of sugarcane bagasse arise in several areas of the region, but large-scale development based on bagasse would as a rule only be possible in areas where alternative fuels could be easily supplied. The most promising possibilities seem to lie in Cuba, Brazil, and Mexico.

Besides mechanical and chemical pulp, other fibrous raw materials in the form of waste papers, rags, rope cuttings, etc., are required in the paper industry. Properly organized

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recovery of waste paper and rags should enable the increased demand to be met, though it should be noted that special efforts will be required since paper consumption is likely to be more dispersed, making waste paper collection more difficult.

Table XXX summarizes the potential annual yield from certain fibrous material resources capable of numerical estimation. These, though representing only a small fraction of the total resources, give an annual supply of about 7 million tons of raw material, considerably more than the estimated 1960 requirement of 2.5 millions. As has already been stated, conifers alone—which represent but 5% of the total forested area—would be sufficient to satisfy the continent's requirements up to that time.

In the short term, attention is likely to be focused on utilizing the coniferous resources of Chile, Brazil, and Mexico, the bagasse resources in Cuba, Mexico, and Brazil, and straw in Argentina. The eucalyptus plantations in Brazil and the temperate hardwood resources of Chile will also be of great importance for short term development.

The conifers are, however, limited in extent as compared with the tropical wood resources and for technical reasons it is desirable to spare them, in some degree, for those uses in which they cannot be replaced by other, shorter-fibered materials.

As the pulp and paper industry in Latin America develops, each individual project should therefore be judged against the background of the pattern of the region's total fibrous resources to insure their wisest use in the long term. The study of tropical wood resources should be pressed forward with the aim of ultimately establishing large-size, economic mills. This implies the setting up of model mills in appropriate places in the immediate future and surveying all the economic factors involved in the operation of such mills.

It is a striking fact that though Latin American output of paper and board has roughly trebled since 1935, imports from other regions have not diminished. On the contrary, imports have risen from less than 400,000 tons in 1935 to over 600,000 tons today. Had there been no increase at all in the continent's own production, consumption would have remained far below its present level; it may in fact be doubted whether imports would greatly have exceeded their present figure. The evidence suggests that a lack of local supply tends to frustrate consumption rather than to create an equivalent demand for imports.

It has been shown that, in aggregate, projected pulp and paper developments in the region fall short of the expansion that will be required if paper and board consumption is to rise in harmony with the region's economic growth and cultural advance, even if we assume that pulp and paper imports into the region can be maintained at their present level. Moreover, it should be pointed out that the assessment of future developments has by no means been a critical one; undoubtedly some of the projects listed will prove, after investigation, to be impracticable or uneconomic.

Three main conclusions therefore follow:

1. The extent to which paper and board consumption falls short of the level appropriate to the region's general development will depend on the rate at which native capacity expands and on the region's capacity to import.
2. There is urgent need for encouraging pulp and paper developments within the region.
3. The region's import needs are not likely to diminish; how far imports will rise will depend on the region's capacity to import.

Because most governments within the region are keenly aware of the desirability of expanding their countries' pulp and paper capacity, it is of the highest importance that they should be discouraged from lending support to projects which may not be well conceived.

The second part of this report will appear in the July issue of *Tappi*.

Table XXX. Potential of Selected Latin American Resources of Fibrous Raw Materials—Potentials which Could Be Estimated Numerically

Thousand of tons of raw material per annum

Country	*Zone*	*Conifers*	*Eucalyptus*	*Other non-conifers*	*Wheat straw*	*Bagasse*	*Total*
Argentina	Misiones	80	...	...	200[a]	...	. .
	Wheat area	...	...	...	200[a]	...	...
	Tucuman	...	...	...	...	70	350
Bolivia		...	...	[a]	...	...	...
Brazil	Amazonia	...	...	65[a]	...	...	...
	São Paulo	...	480	...	...	[a]	.
	Paraná	700[a]	...	...	...	...	.
	Sta. Catarina	300[a]	.	...	.	...	...
	Rio Grande do Sul	150[a]	...	...	...	...	...
	Pernambuco	...	...	...	...	[a]	1695
British Guiana		...	...	[a]	...	...	...
Chile	Concepción	2000	...	...	...	...	...
	Valdivia	...	...	650	...	...	2650
Colombia		...	...	400[a]	...	...	400
Costa Rica		...	...	[a]	...	...	...
Cuba	Camagüey	...	...	...	...	80	...
	Oriente	...	...	...	...	75	...
	Cienfuegos	...	...	...	...	130	285
Dominican Republic		...	...	...	40	...	40
Ecuador		...	...	400	...	...	400
Guatemala		[a]	...	110[a]	...	...	110
Honduras		[a]	...	...	...	...	...
Mexico	Chihuahua	160[a]	..	...	...	...	...
	Durango	125[a]	...	...	...	...	...
	Michoacan	120	...	...	...	...	...
	Guerrero	200	...	...	...	...	...
	Yucatan	...	...	325[a]	...	...	930
Paraguay		...	...	[a]	...	...	...
Peru		...	...	30[a]	...	...	30
Surinam		...	...	[a]	...	...	...
Uruguay		...	...	...	[a]	...	...
Venezuela		...	...	...	[a]	[a]	...
Total		3835	480	1980	240	355	6890
Pulp equivalent (1000 tons):		1540	190	800	75	170	2775

[a] Refers to additional large potentials, the extent of which was not calculated.

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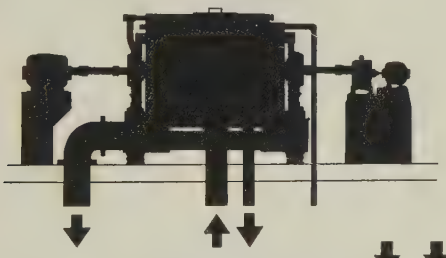

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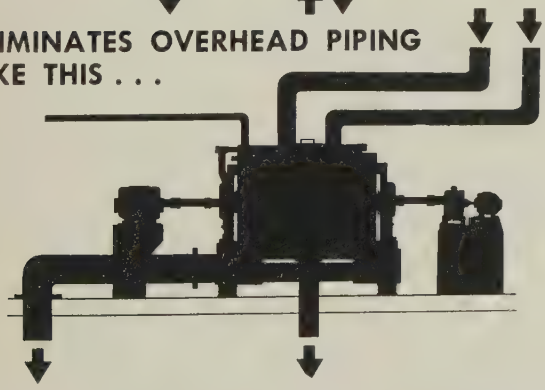

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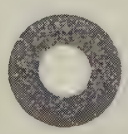

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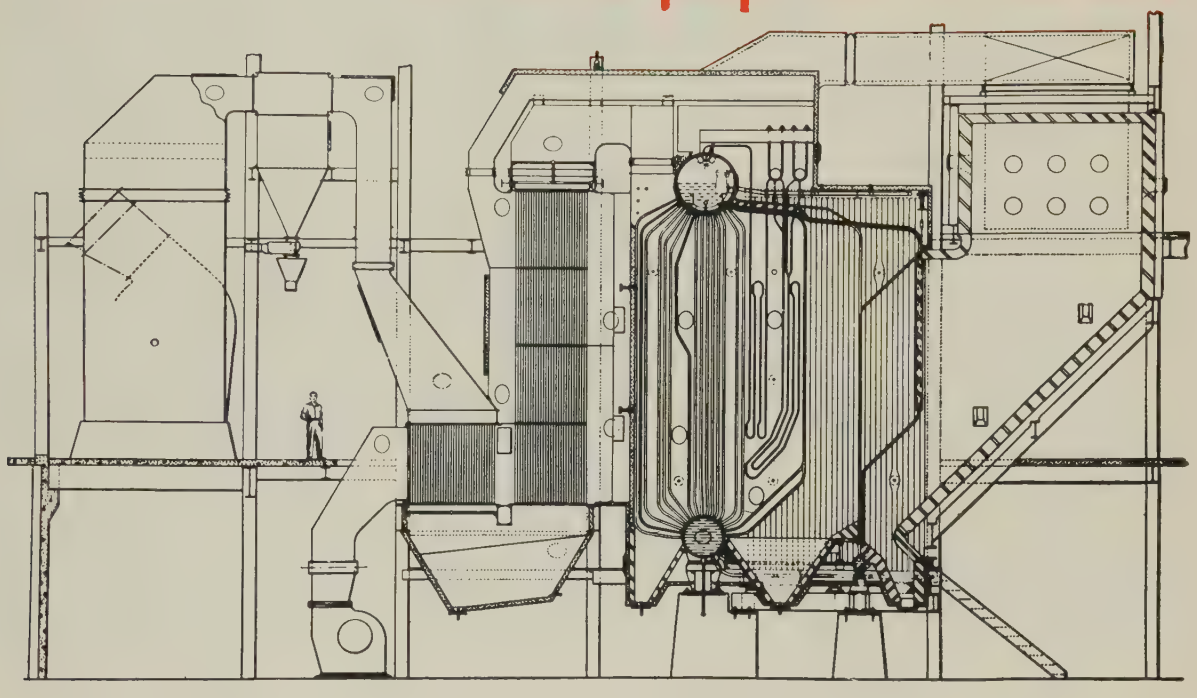


Ketchikan Pulp Company—the first pulp mill in Alaska—will produce dissolving pulp employing the Magnesium Bisulphite (MgO) process. This will be the first new plant to use this process.

B&W is the exclusive licensing agent for the MgO process. Each of the two B&W heat and chemical recovery units for this plant is designed to generate 93,000 lb of steam per hour . . . will consist of a two-drum bent-tube boiler with superheater designed to operate at 860 psi and 825 F total temperature, and equipped with Y-jet liquor atomizers set in a refractory furnace.

In addition to the recovery units, two B&W two-drum Stirling boilers are on order, to be fired with oil and bark. Each power boiler will generate 160,000 lb of steam per hour at 860 psi and 825 F total steam temperature.

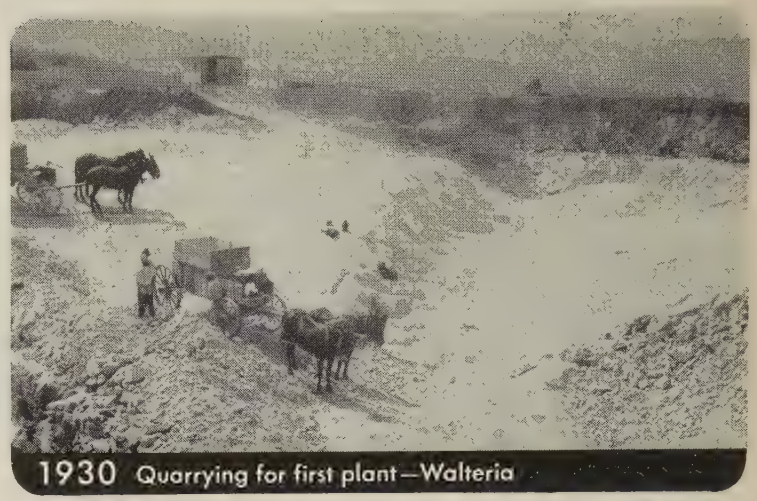
B&W invites your inquiries relating to heat and chemical recovery problems for both the sulphite and sulphate pulping processes. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

BABCOCK & WILCOX

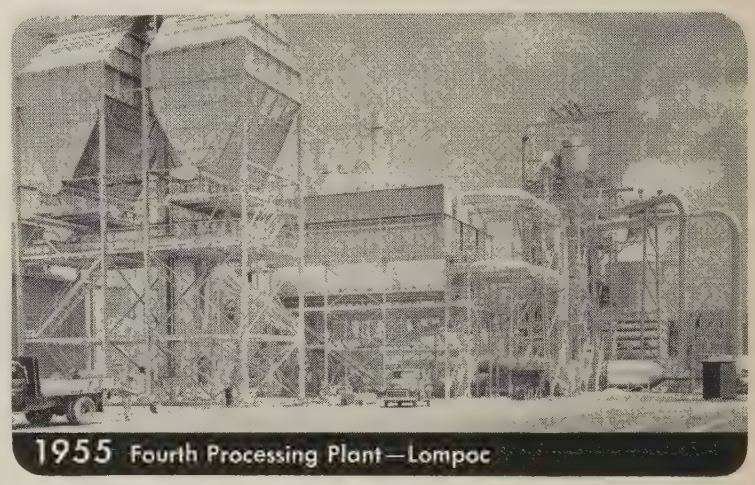
BOILER DIVISION

P-779

a quarter of a century separates these DICALITE pictures



1930 Quarrying for first plant—Walteria



1955 Fourth Processing Plant—Lompoc

They didn't continue very long—the horse-and-wagon, hand-quarrying methods of our early days. For Dicalite was founded on the idea of *development,* of promoting new uses for that little-known (in 1930) material, diatomite, and working out improved processing methods.

The succeeding 25 years have, we believe, proved the soundness of that idea. Today diatomite . . . also called diatomaceous silica, diatomaceous earth or D.E. . . . has important uses in more than 200 industries, and Dicalite has helped in the pioneering and development of many of these uses. Dicalite products, which now number more than 50, have a valued place in the brewing, pharmaceutical, chemical, sugar, food, paint, paper and other large industries, as filteraids, fillers, insulation and in other capacities.

And Dicalite itself has grown—because of this basic idea of development—from 1930's one deposit, one plant, to 1955's four processing plants and deposits in three states. Four locations, four plants, served by four different railroad systems, insure a continuing, *dependable* supply of the diatomaceous materials upon which many industries rely.

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

DEPENDABLE SERVICE TO INDUSTRY 25 YEARS Dicalite 1930-1955

DICALITE DIVISION, GREAT LAKES CARBON CORP. • 612 SOUTH FLOWER ST., LOS ANGELES 17, CALIFORNIA

Wet-Strength at Low Cost with UFORMITE 711

UFORMITE 711 gives paper wet-strength at low cost with almost any type of furnish—kraft, sulfite, groundwood, or rag.

UFORMITE 711 is highly efficient over a wide range of resin-to-pulp ratios. As little as 0.5 percent gives good wet-strength; 3.0 percent gives maximum values. It is easy to mix: no acid pre-treatment, aging or special equipment is required. The pH can be controlled with acid, alum, or blends of each.

Other Rohm & Haas chemicals for the paper industry include hydrosulfites for bleaching woodpulp; resin emulsions for paper coating and saturation; surface active agents, pitch dispersants, deodorants, and bactericides. Write for samples and technical information.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

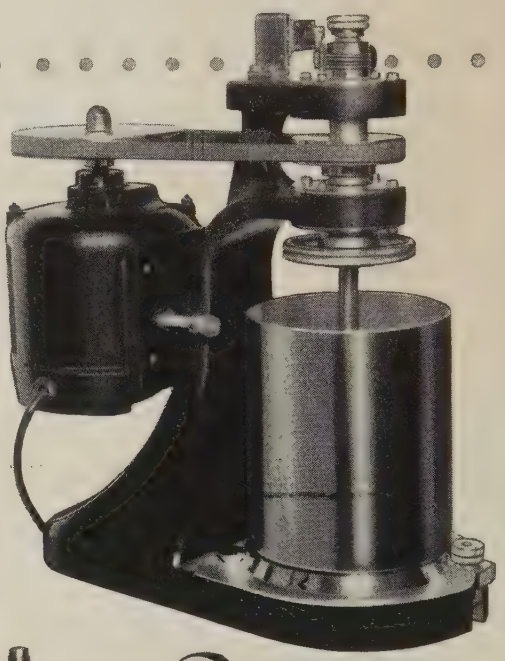
Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

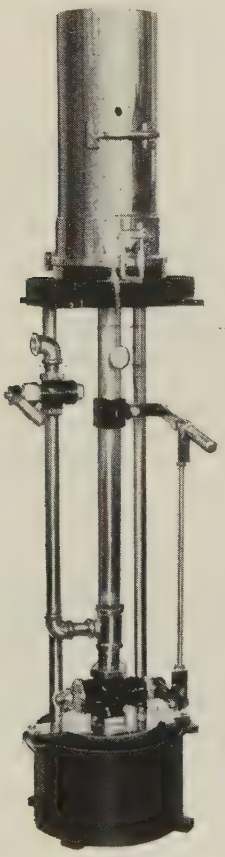
UFORMITE *is a trade-mark,*
Reg. U.S. Pat. Off. and in principal foreign countries.

TAPPI STANDARD

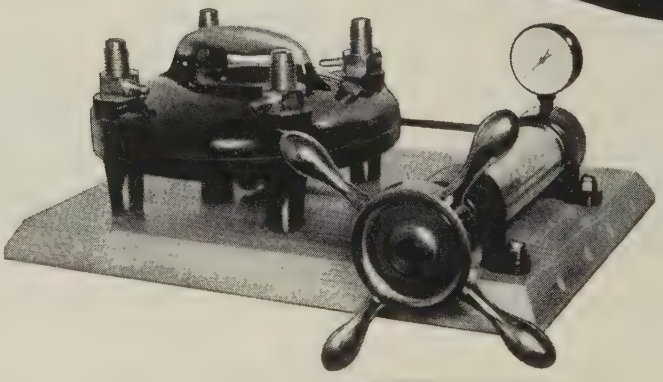
Pulp Testing and Sheet Making Apparatus



TAPPI
Disintegrator



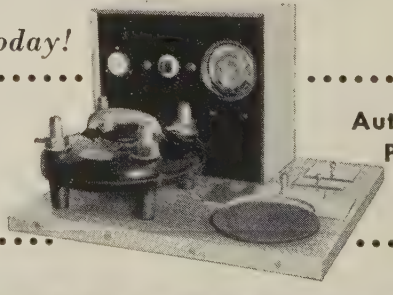
TAPPI
Sheet Making
Machine



TAPPI
Pump and
Press

Write for complete information Today!

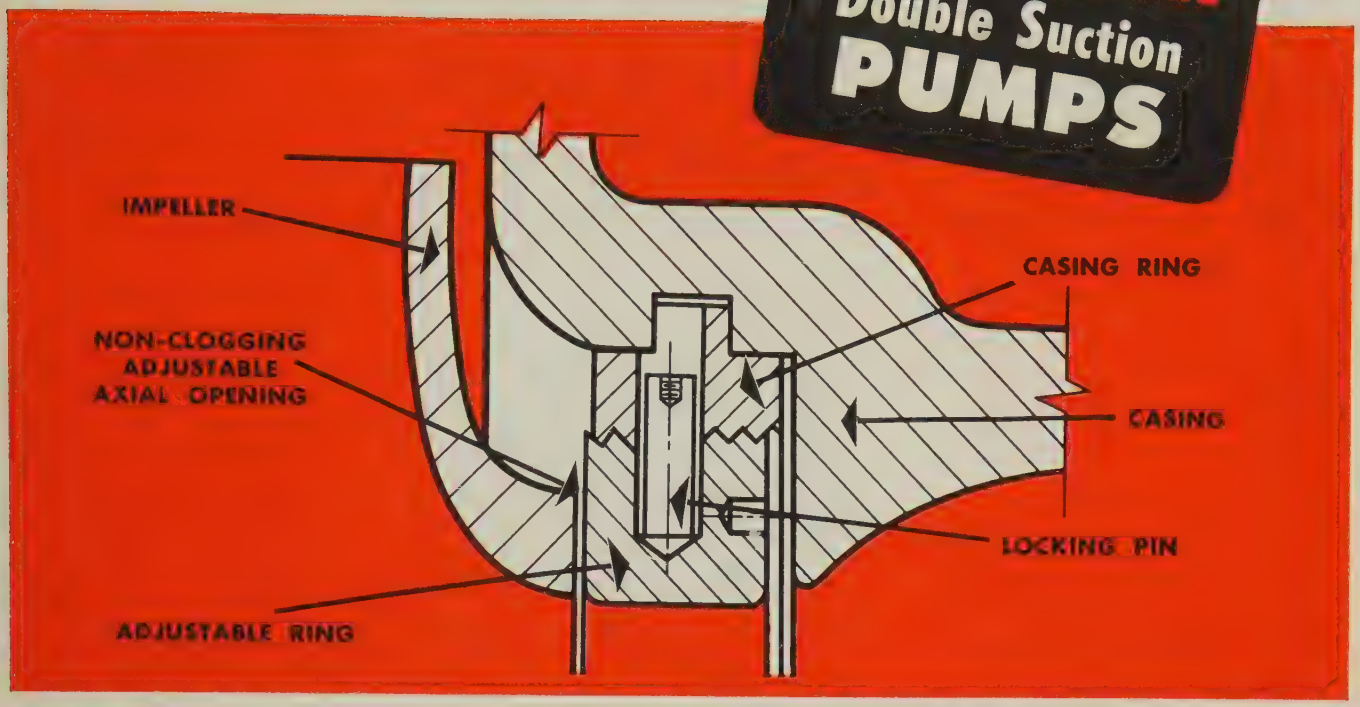
Also Available...
AUTOMATIC COUCHING AND PRESSING EQUIPMENT
as developed by Hermann Mfg. Co.



Automatic
Press

THE HERMANN MANUFACTURING CO.
LANCASTER, OHIO

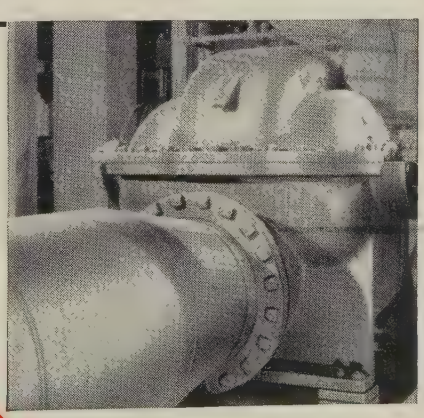
ALLIS-CHALMERS
Double Suction
PUMPS



This wearing ring design pays off in Long Life... Low Maintenance

- ***You can compensate for wear***
- ***. . . eliminate seizing damage***

This unique Allis-Chalmers pump design features adjustable clearance wearing rings with an *axial* rather than a *radial* opening. It will cut your pump costs by keeping efficiency high in spite of wear and by preventing damage due to seizing of impeller by stock in the wearing ring clearance. Ideal for fan pump, white water, light stock, or small solids in suspension.



This 24 by 24 Type SK, 15,000-gpm, 30-ft head fan pump moves stock from wire pit to machine head box at Potlatch Forests, Inc., Lewiston, Idaho.

A-4424

To Adjust Clearance for Wear

Remove pin, turn threaded inner ring until clearance is correct, replace the pin. Correct clearances not only keep efficiency high but tend to exclude solids and eliminate clogging.

Radial Clearance Prevents Seizing

Wearing rings on Allis-Chalmers pumps have axial clearance; thus solids work themselves free. And — the temporary added load on the thrust bearing causes no trouble because the bearing is built big enough to take it. In pumps having ordinary wearing rings, with radial clearance, solids wedging between the ring and impeller may deflect the shaft — cause the impeller to seize.

Stainless steel wearing rings are carried in stock for 16 by 14 and smaller-sized pumps.

★ ★ ★

See how these and other features keep pump costs down. Find out, too, why it pays to specify Allis-Chalmers for the complete pumping unit — pump, motor, drive, and control. Contact your district office or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for bulletins 08B6146, 52B7112 and 52B7839.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

HOW TO BUY RUBBER COVERED ROLLS

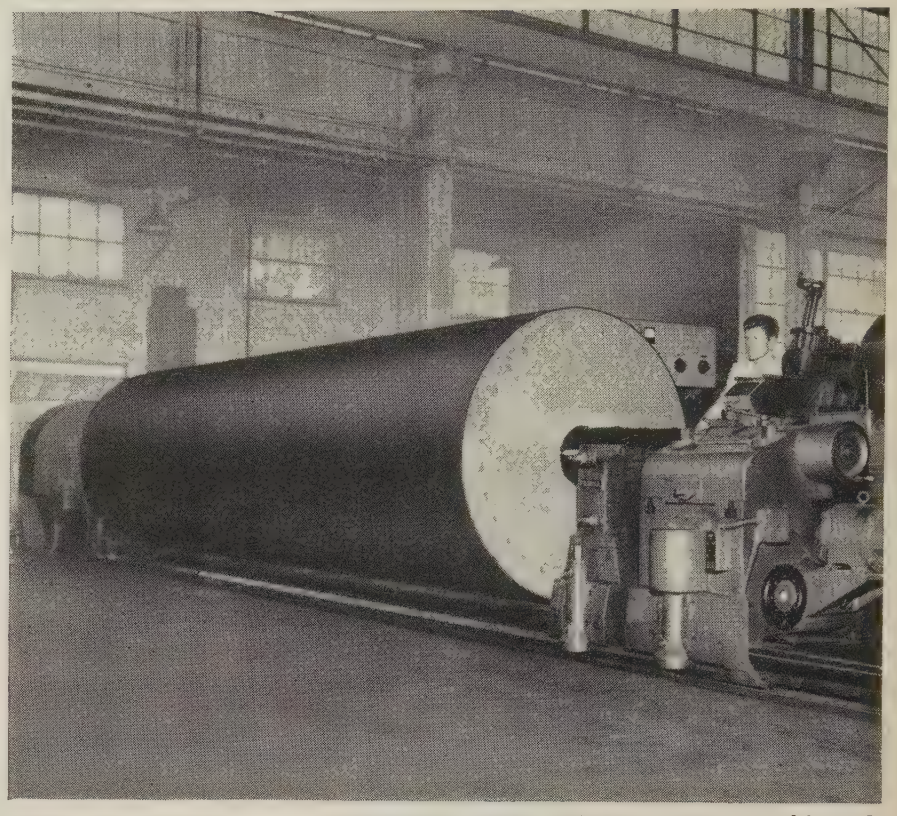
TO MEET SPECIAL ROLL REQUIREMENTS

. . . and get "More Use per Dollar"

Insist on roll covering that is custom-made by roll covering specialists . . . with large, up-to-date equipment and facilities.

Separation of the rubber from the metal core is a primary cause of failure with ordinary rubber covered rolls. Look for a company who has developed a superior rubber to metal bond that prevents cover separation. Make certain the company that handles your roll covering job has the specialized experience and know-how for producing the correct rubber compound for your requirements to prevent cracking, hardening, corrugation and oxidation. Be sure they have the facilities to handle your job regardless of size. Determine whether they have the modern equipment to vulcanize and grind your roll covering to the precise diameter you require . . . to insure uniform and permanent density for your operations.

Specify rubber covered rolls custom-made to meet your specific operating conditions . . . specify Manhattan Rubber Covered Rolls.



Largest grinder and largest roll covered in U. S. Grinder can take rolls 35 ft. x 62" diameter.

MANHATTAN RUBBER COVERED ROLLS

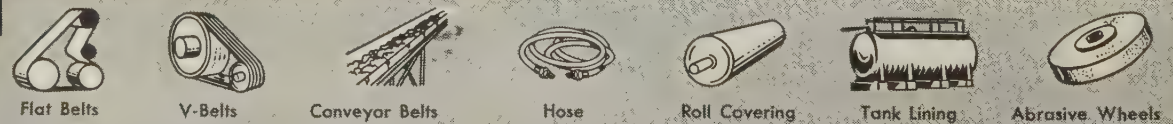
Over 60 years of experience is ready to serve you at Manhattan for the development and production of roll coverings to meet the special needs of your plant. Manhattan roll covering specialists have developed an inseparable bond of rubber to metal core and roll cover compounds that virtually eliminate troubles due to cracking, hardening or corrugating. Modern precision roll grinding and vulcanizing facilities can handle the largest rolls made and insure accuracy of dimension within .002". Custom-made to give you uniform production quality, Manhattan Rubber Covered Rolls assure permanent density and long, trouble-free service under all working conditions. Discuss your job requirements with an R/M roll covering specialist. He'll tell you why Manhattan Rubber Covered Rolls last much longer . . . give you "More Use per Dollar".

RM-518

ROLL COVERING PLANTS AT PASSAIC, N. J. — NEENAH, WIS. — NORTH CHARLESTON, S. C.

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



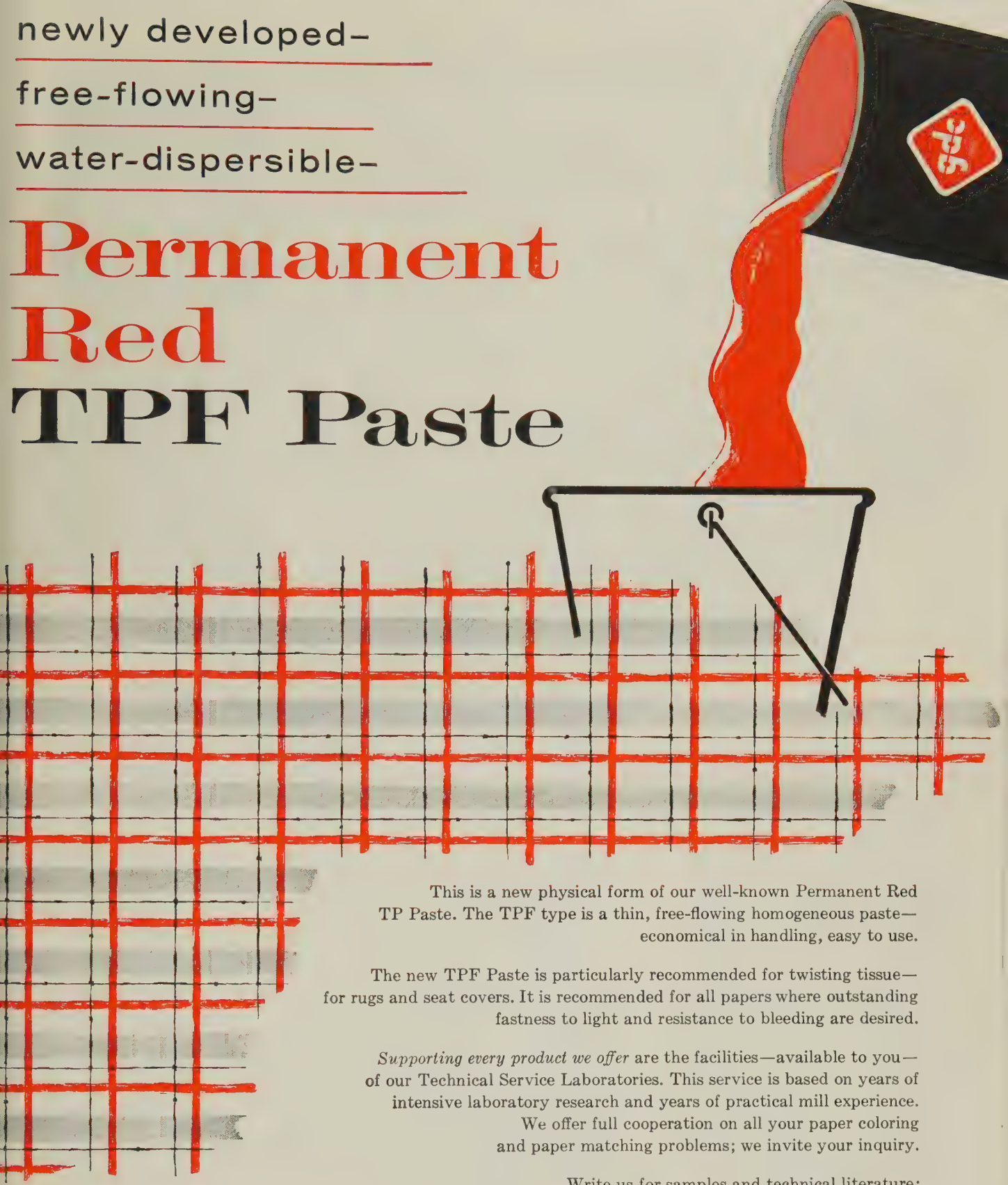
Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Bowling Balls

newly developed–

free-flowing–

water-dispersible–

Permanent Red TPF Paste



This is a new physical form of our well-known Permanent Red TP Paste. The TPF type is a thin, free-flowing homogeneous paste—economical in handling, easy to use.

The new TPF Paste is particularly recommended for twisting tissue—for rugs and seat covers. It is recommended for all papers where outstanding fastness to light and resistance to bleeding are desired.

Supporting every product we offer are the facilities—available to you—of our Technical Service Laboratories. This service is based on years of intensive laboratory research and years of practical mill experience. We offer full cooperation on all your paper coloring and paper matching problems; we invite your inquiry.

Write us for samples and technical literature; call upon our skilled technical service.

From Research to Reality

gdc gaf

GENERAL DYESTUFF COMPANY

A SALES DIVISION OF GENERAL ANILINE & FILM CORPORATION

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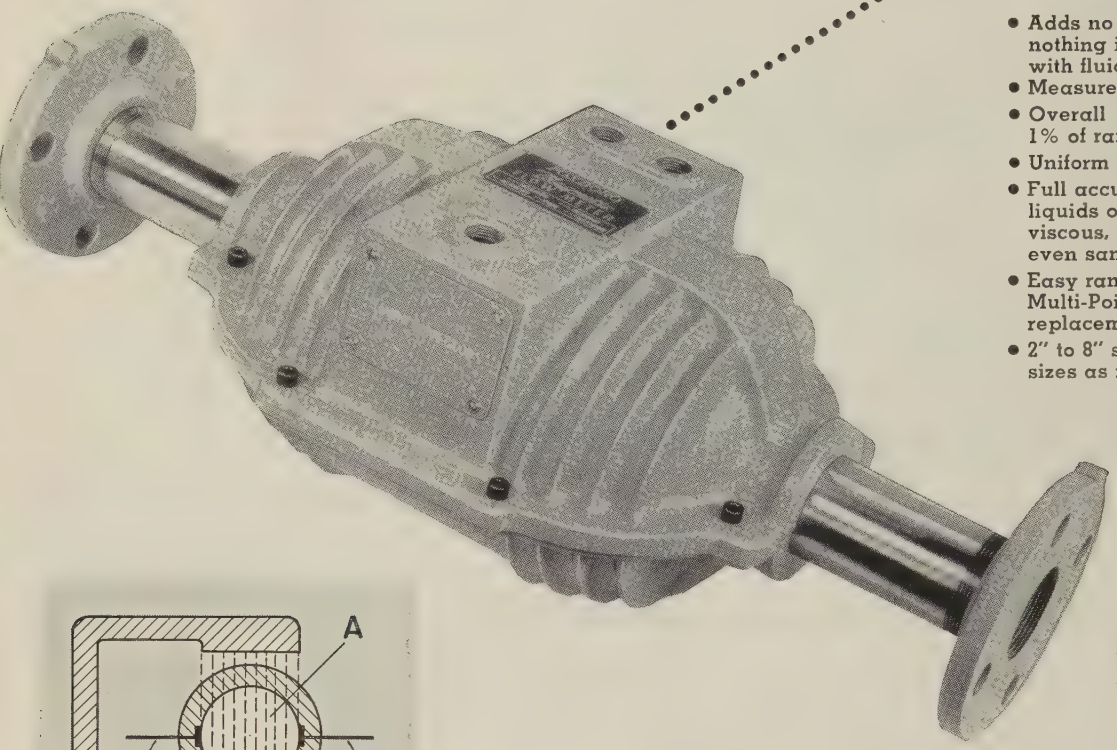
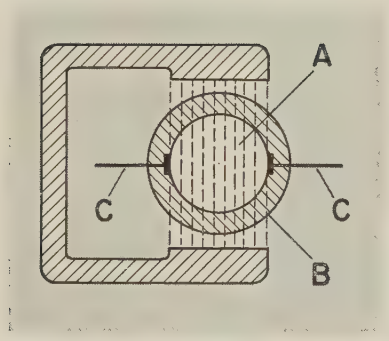
BOSTON • CHARLOTTE • CHATTANOOGA • CHICAGO • LOS ANGELES • NEW YORK • PHILADELPHIA • PORTLAND, ORE. • PROVIDENCE • SAN FRANCISCO

NEW! a flow meter with no flow restrictions!

- Adds no pressure drop — nothing inside pipe to interfere with fluid flow.
- Measures fluid velocity directly.
- Overall accuracy better than 1% of range over entire scale.
- Uniform flow scale.
- Full accuracy sustained even on liquids other meters can't handle: viscous, corrosive, or pulpy — even sand-water slurries.
- Easy range change — either by Multi-Point Switch or range coil replacement, as preferred.
- 2" to 8" sizes standard — larger sizes as required.



FOXBORO MAGNETIC FLOW METER



SIMPLE, TROUBLEFREE, OPERATION

The Foxboro Magnetic Flow Meter operates on the same principle as a power generator. A magnetic field (A) is maintained through a standard pipe section (B) of stainless steel or other non-magnetic material. This pipe section is lined with Kel-F® or other insulating material. Liquid passing through pipe acts as moving conductor, generating an electric voltage which varies in proportion to liquid's average velocity. Flush electrodes (C) in pipe wall "pick up" this voltage which is recorded in desired flow units by Dynalog Electronic Recorder or Controller.

This premium-performance meter measures *magnetically* the flow rate of virtually any liquid except hydrocarbons. It completely ignores such common metering headaches as turbulence, suspended solids, and variations in conductivity, density, and viscosity. It even measures reversing flows.

Installation is simple. The magnetic spool piece connects into the line like any equivalent length of pipe — no seals, purges, meter runs, or straightening vanes required. Connects by 2-conductor cable to remote Dynalog Electronic Flow Recorder.

Maintenance is practically eliminated. There are no pressure taps to become plugged or frozen, no working parts to foul.

Foxboro Magnetic Flow Meters are already in use on such widely different liquids as beer, sand-and-water, rosin size, rock-and-acid slurry, viscose, and highly corrosive liquid detergent. Find out how this precise, troublefree flow meter can help *your* processing. Write for complete details.

THE FOXBORO COMPANY, 786 NEPONSET AVENUE, FOXBORO, MASS., U. S. A.

FOXBORO
REG. U. S. PAT. OFF.

Foremost in FLOW METERING

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Gives you complete Color Measurements in less than 30 seconds!

Here's an easy, precise way of making a complete set of color measurements in less than 30 seconds.

The Colormaster Differential Colorimeter measures the color transmission and reflectance of almost any substance. It reproduces measurements, for example, better than .02% reflectance units. Results can be read directly from the instrument's dial.

IDEAL FOR USE IN PROCESS CONTROL APPLICATIONS OF

- Papers
- Textiles
- Paints
- Liquids
- Pigments
- Slurries

More Sensitive than Human Eye

The Colormaster is much more sensitive to differences in similar colors than the human eye. Chance of human error in this respect is eliminated Here, too, can be seen the many definite advantages the Colormaster gives in maintaining color standards within exacting limits.

Send for Bulletin

Fill-in and mail the coupon today for our informative bulletin on the Colormaster. It describes in detail this latest development in color measurements.

MEECO Instruments

MANUFACTURERS ENGINEERING & EQUIPMENT CORP.
York and Sunset Lane **Hatboro, Pa.**

Please send me the descriptive bulletin on your Colormaster Differential Colorimeter.

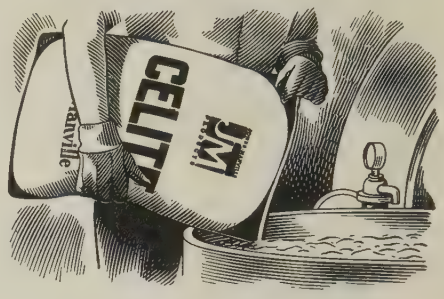
Name .....

Company .....

Address .....

City ..... Zone ..... State .....

How Celite eliminates pitch trouble



...AT NO COST!

MANY PAPER MILLS have turned to Celite* diatomite powders as the simplest and most economical way to counteract pitch trouble. Celite pays for itself because at least 50% of the Celite is recovered in the finished sheet. In addition, the elimination of down time, due to pitch, results in further savings.

A test run in your mill will quickly demonstrate these advantages of Celite. Because of Celite's porous, absorbent characteristics, the microscopic particles surround and coat the pitch, prevent it from adhering to machines. And since the Celite-coated particles are largely retained in the sheet, they do not build up in the stock or white water system.

Celite is also used in other ways to improve finished sheet. It can increase opacity up to 50% . . . it can add higher brightness at lower cost . . . and provide better ink receptivity and absorption, too.

To prove these advantages of Celite, a Johns-Manville Celite Engineer will gladly assist you in making trial runs in your mill. There is no charge for his services. Simply write Johns-Manville, Box 60, New York 16, N. Y.

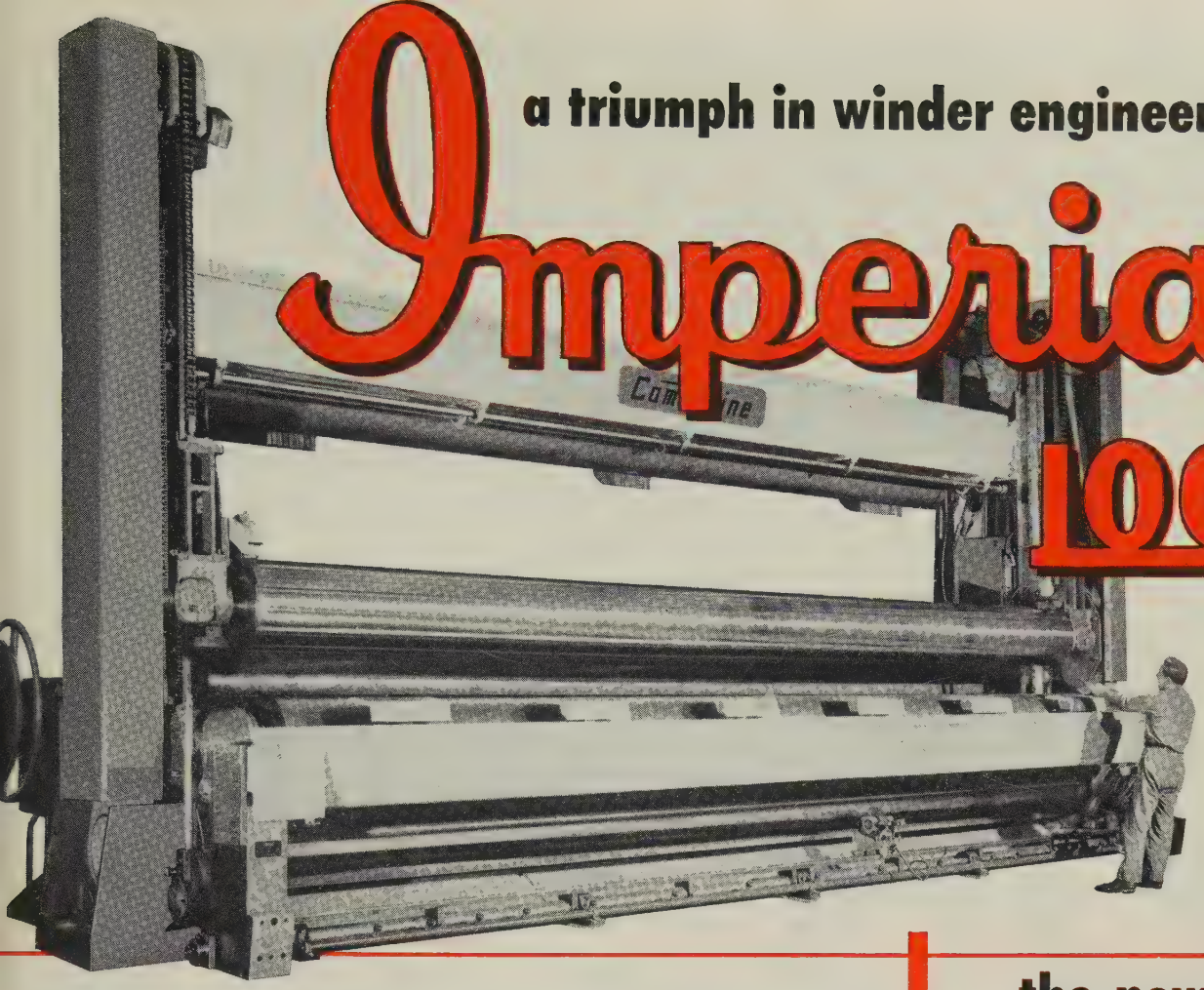
*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CELITE PRODUCTS FOR THE PAPER INDUSTRY

a triumph in winder engineering!

Imperial 100



ADAPTABILITY: The Imperial handles all weights and types of paper and board. A unique suspension, and adjustable automatic counterbalancing, provide optimum torque and pressure distribution for all grades. The machine can be equipped with either score-cut or shear-cut slitters, or a combination of both, to provide the best slitting method for each of your materials. The Imperial is available in 42″ and 72″ rewind capacities for jumbo roll winding. It can also be equipped with semi-automatic attachments for high speed production of small diameter counter rolls.

SPEED: The Imperial runs at extraordinary rates both when accelerating and at constant speed . . . meets all production needs. Conservative, field-proven engineering, and precise dynamic balancing of all rotating elements, positively assure smooth operation from start to maximum speed. All rolls and main drive elements use heavy duty, oil lubricated, precision anti-friction bearings. The heavy, extra rigid framing dampens vibration. Shock absorbing, rewind "hugging" suspension of the riding roll, and friction inhibiting rewind shaft retention, contribute to superior web and strip control. The super-precision heavy duty slitting elements assure accurate clean-cut edges at all speeds, and the heavy duty driving elements meet all power requirements.

DURABILITY: The Imperial is designed and built for many years of trouble-free service. It has extra heavy construction throughout, with hardened and ground vertical ways for both the riding roll and rewind shaft carriages. The bearings and gears have a life expectancy in excess of 100,000 hours. The gear drive is designed to eliminate dynamic loading and is equipped with a water-cooled, forced-feed lubricating system. Centrifugal lubricant and dust seals are used on all high speed elements . . . and the superior shock absorbing rewind shaft handling equipment assures longer, lower-cost operation.

CAMERON MACHINE COMPANY 61 Poplar Street Brooklyn 1, N. Y.

the new Camachine®

heavy duty mill type slitter and winder

Job-proven for dependability, economy and roll quality at speeds never before achieved!

FEATURING extraordinary ease and speed of handling through:

QUICK SET, PRECISION SLITTERS

HYDRAULIC RIDING ROLL AND REWIND BEARING LIFTS

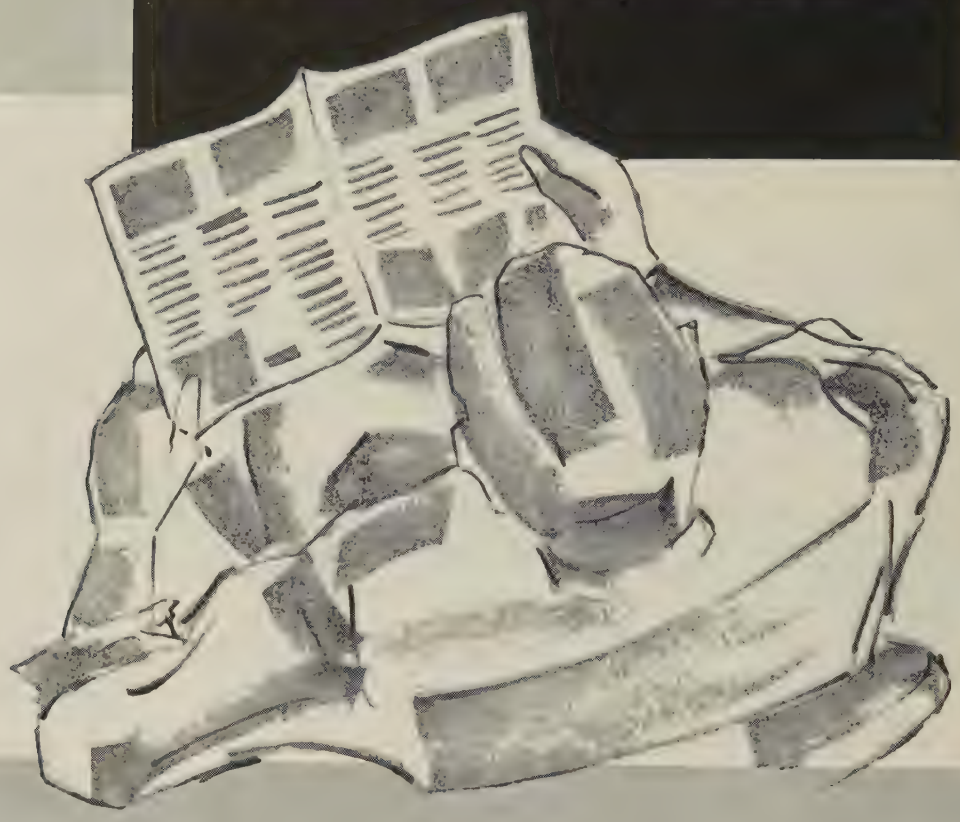
HYDRAULIC ROLL EJECTOR AND REWIND SHAFT INJECTOR

SIMPLE CENTRALIZED CONTROLS

DIRECT, EASY THREADING

The performance of the new Imperial speaks for itself in the mills it serves. Write on your company stationery for the complete story about the Camachine Imperial. Let us show you why it is the most productive, adaptable and durable mill type slitter and winder you can own.

The Bauer Story on Hard Board and Insulating Board



Comprehensive information on hard and insulating boards is assembled in a binder available to a limited number of plant managers and technicians who are interested in the subject.

The contents are as follows:

1. Discussion of History and Processes.
2. Table of Approximate Product Costs.
3. Table of Approximate Plant Costs.
4. Reprints of Seven Relevant Articles from THE LUMBERMAN, PAPER TRADE JOURNAL, PULP & PAPER, and THE TIMBERMAN.
5. Bulletins on Bauer Refiners.
6. Three Flow Diagrams of Plants and Systems.

If you desire the treatise, please write on company stationery and give your official title.

The Bauer Bros. Company

1757 Sheridan Ave. • Springfield, Ohio

"Mersize RM Dry makes Groveton's entire mill operation more efficient."

—John Paugh, Mill Superintendent, Groveton Papers Co., Groveton, N. H.

Another great American papermaker, Groveton Papers Co., Groveton, N. H., producers of Triad fine-quality mimeograph bond and duplicator papers, has switched to Mersize RM Dry. Here's why:

"We realize a high efficiency throughout our plant with Mersize RM Dry," says Mill Superintendent John Paugh. "We have *substantially reduced costs* and *time* spent by adding Mersize RM Dry directly to the beater."

Murray Atkinson, Groveton's beater room foreman, reports: "Easy-to-handle Mersize RM Dry smooths out beater room operation. The men working with Mersize appreciate its *low dusting* and *non-irritating* qualities."

If you use dry size, check these other Mersize RM Dry advantages:

Light color—Mersize RM Dry is very light in color, resists darkening with age . . . produces high-brightness paper comparable to the lightest rosin size.

Low foam—Mersize RM Dry's low foam index helps eliminate countless production problems.

For full information on how Mersize RM Dry can make your mill process more efficient, write Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Box 478-X-3, St. Louis 1, Mo.

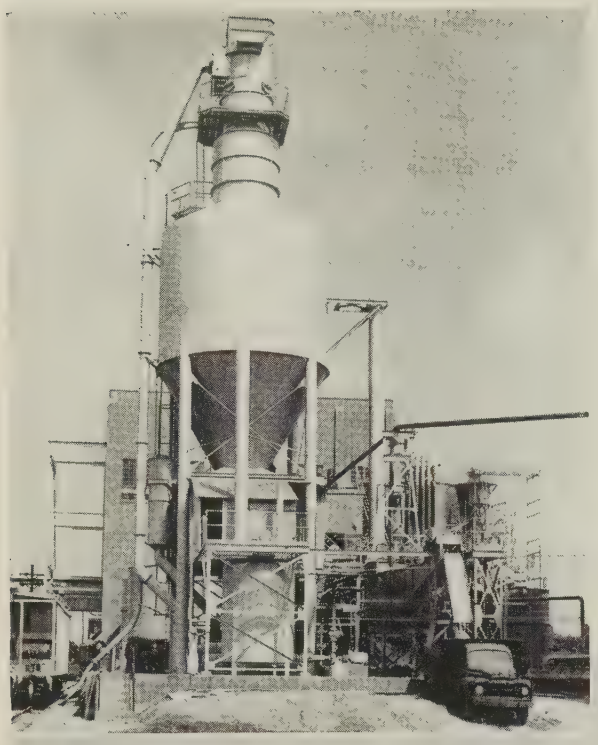
Check list of Monsanto's complete line of fortified sizes:

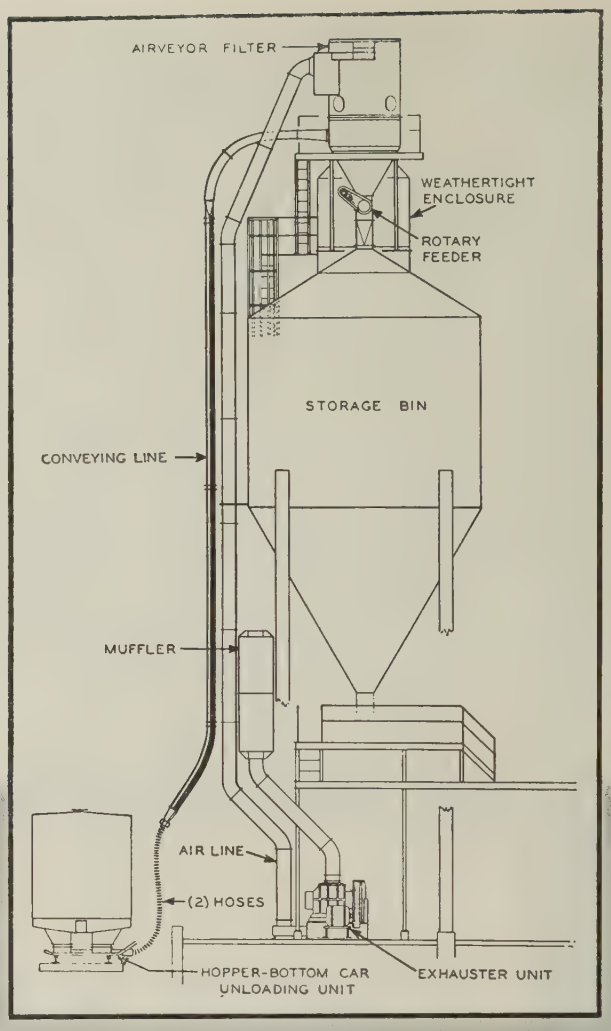
Mersize CD-2—Concentrate, for use with rosin size
Mersize CD-2 Dry—Concentrate in dry form
Mersize RM 70%—Complete fortified paste size
Mersize RM 77%—Complete fortified paste size

Mersize: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS—PLASTICS

SERVING INDUSTRY...WHICH SERVES MANKIND





AGAIN . . .

Mead Corporation installs The AIRVEYOR®

Flowing mill-supply chemicals, such as lime, soda ash, salt cake, starch and clays with the Airveyor—unloading cars to storage or in-plant conveying—is the simplest, most economical conveyor for your plant.

Mead Corporation has learned from experience that it pays to use the Airveyor, having continued to install such equipment wherever possible and practical, until today in four of its plants, nine such systems are in use. One of the most recent installations is that for unloading lime from cars to storage, at rate of 15 tons an hour, in the Chillicothe, Ohio plant, shown by photograph and drawing above.

The paper industry has learned by experience that the Airveyor is engineered and built for superior performance . . . well over a hundred systems have been installed in various mills in the United States and Canada.

If you have a problem in your handling of mill-supply chemicals, why not let us make a study of your layout . . . chances are we may be able to show you a more efficient and profitable method of operation . . . such a study costs you nothing, obligates you in no way.

Fuller

CONVEYS BY AIR

. . . NOTHING MOVES BUT THE MATERIAL

FULLER COMPANY—CATASAUQUA, PA.

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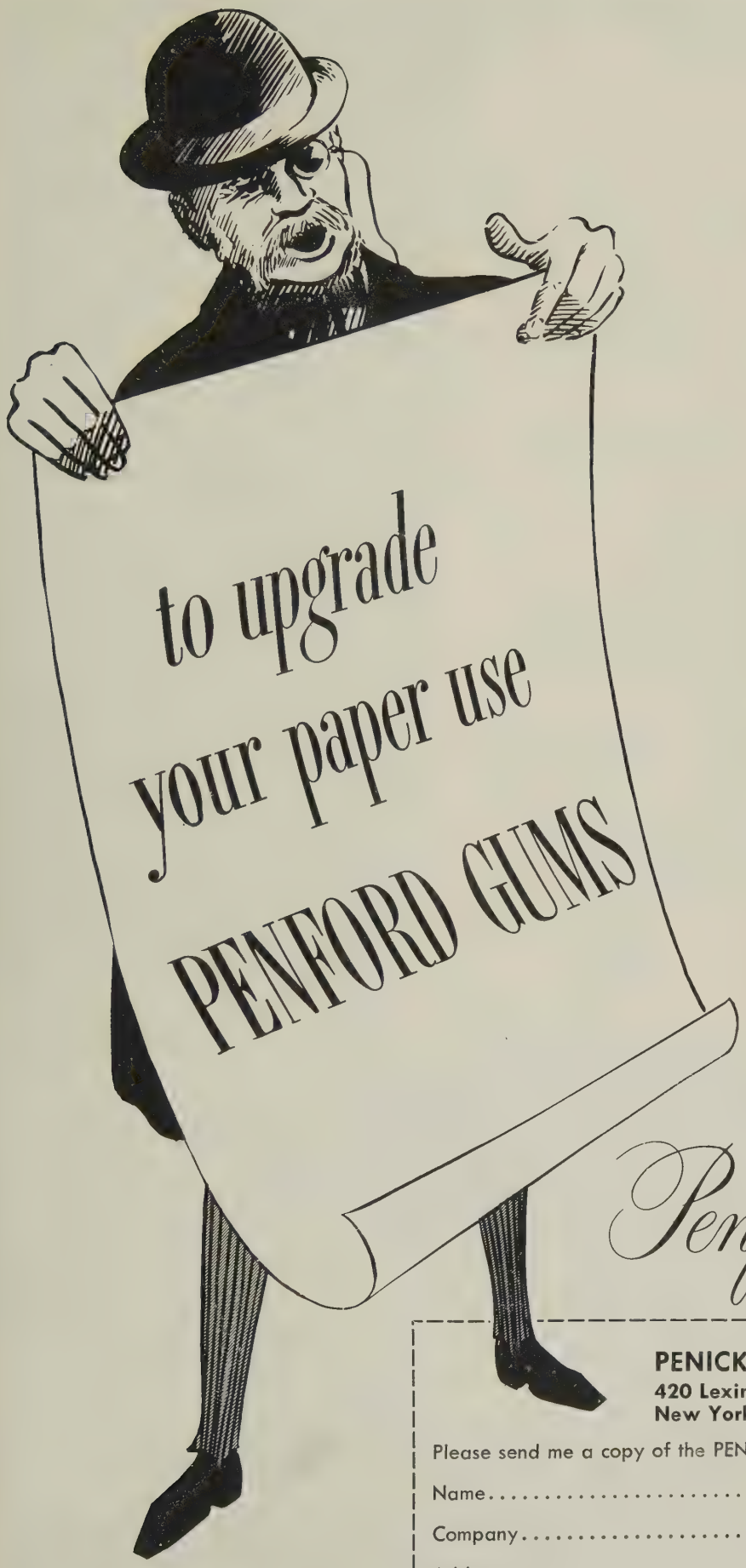
DRY MATERIAL CONVEYING SYSTEMS AND COOLERS—
COMPRESSORS AND VACUUM PUMPS—
FEEDERS AND ASSOCIATED EQUIPMENT

A-190
2326



PENFORD GUMS—starch hydroxy ethyl ethers—have unusual properties that will definitely upgrade your line. You can use PENFORD GUMS with your existing equipment and there are twelve grades to fit any sizing or coating operation.

PENFORD GUMS are now available in various different degrees of substitution and cover a range from the highest viscosity starches to the most fluid dextrines.

Investigate fully the virtues of PENFORD GUMS. Call our technical representative for a laboratory evaluation or mill demonstration. He will be glad to cooperate and to recommend the grade best suited for your operation. PENICK & FORD, LTD., Incorporated, 420 Lexington Avenue, New York 17, N. Y.; 806 Bona Allen Building, Atlanta, Georgia; Cedar Rapids, Iowa.

(U. S. Patent Nos. 2,516,632; 2,516,633; 2,516,634)

Penford Gums

PENICK & FORD, LTD., INC.,
420 Lexington Avenue,
New York 17, N.Y.

Please send me a copy of the PENFORD GUM BROCHURE

Name.....Title.....

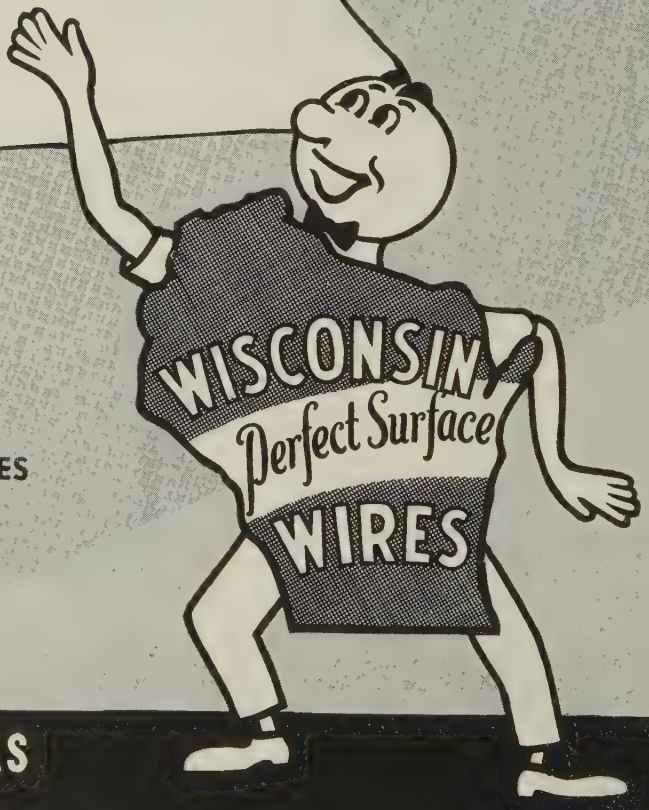
Company.....

Address.....

.....

to maintain
perfect quality
paper production
Use
WISCONSIN
Perfect Surface
WIRES

Expertly made with finest precision equipment from extra select wire. Backed by years, and years of experience is your assurance of the very best.



If You Have Not Seen
Our Color Film
WEAVING WISCONSIN WIRES
We Will Be Pleased to
Send It to You

WISCONSIN WIRE WORKS
APPLETON, WISCONSIN

DOWNINGTOWN

Celebrates

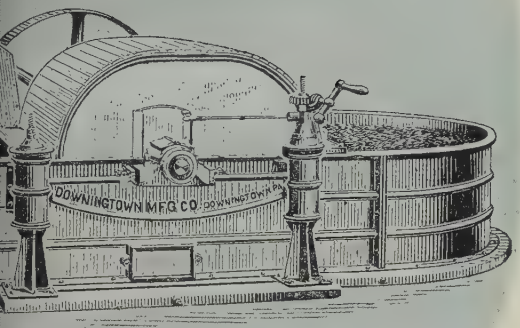
75

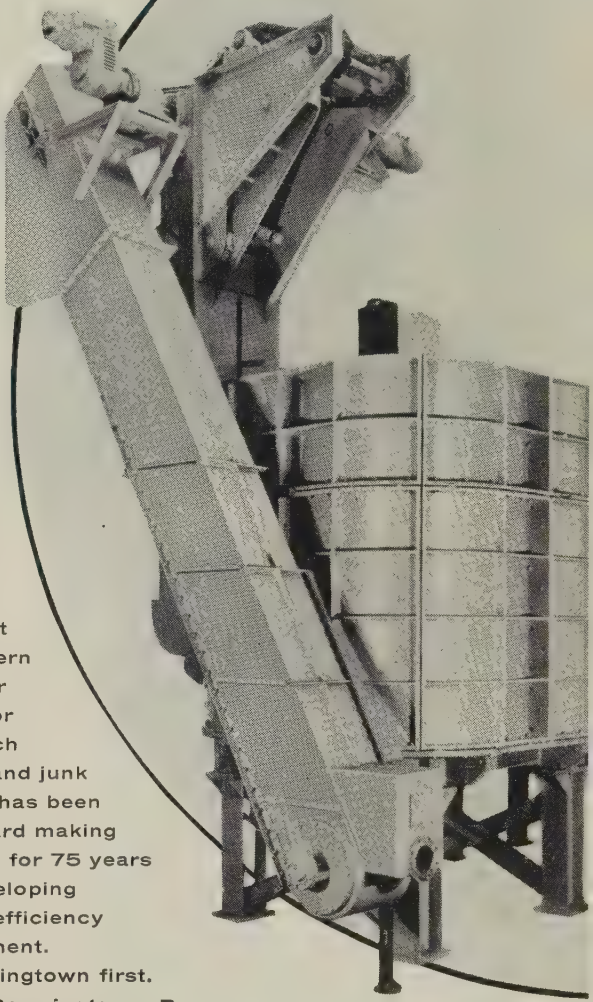
Years of Progress

IN

Stock Preparation Systems

1880 · 1955





Stock preparation equipment has come a long way since the Downingtown Beating Engine at left was first introduced circa 1890. At right is illustrated a modern Downingtown Fibrepulper which is manufactured for both continuous and batch operation...with ragger and junk remover if desired. As it has been with other paper and board making machinery, Downingtown for 75 years has been a leader in developing and manufacturing high efficiency stock preparation equipment.
Be sure to consult Downingtown first.
Downingtown Mfg. Co., Downingtown, Pa.

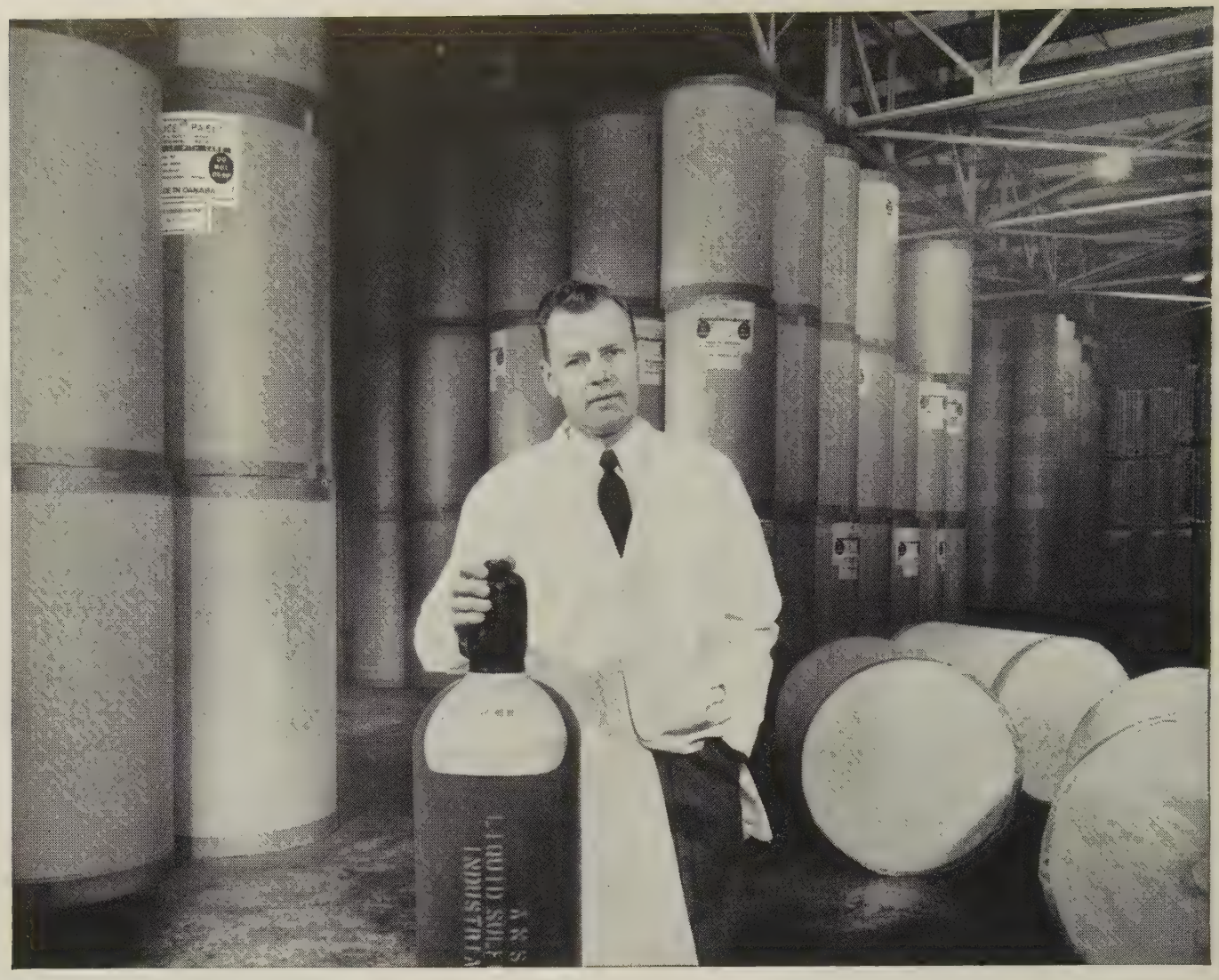
DOWNINGTOWN

DESIGNERS AND BUILDERS OF PAPER, BOARD AND FELT MACHINES

75 *th year*

West Coast Subsidiary:
MONARCH FORGE & MACHINE WORKS, INC.
Portland 10, Oregon

ntatives: UNITED STATES MACHINERY CO., INC., 90 Broad St., New York 4, N.Y., JOHN V. ROSLUND, Pacific Bldg., Portland 4, Ore., THE EMERSON MFG. CO., Lawrence, Mass., KOEHRING-WATEROUS, LTD., Brantford, Ont., Ca



Follow-thru service makes Ansul Sulfur Dioxide your best buy

Your order for Ansul liquid sulfur dioxide includes more than the product, it includes a good measure of service—the kind of service that starts before the chemical is delivered and then goes on and on. We call it follow-thru service. To illustrate our point we would like to quote the production manager of one of our large SO_2 customers. He is referring to the help he received from Ansul while his sulfur dioxide burner was down for extensive repairs.

"Use of the liquid SO_2 and reliable counsel and service by Ansul personnel, definitely got us over the hump. We were able to maintain the high quality of our refining process during a difficult period. An impressive factor was the ease with which we were able to control the liquid SO_2 absorption system. All in all, the operation was very successful."

There are many advantages gained by installing an Ansul SO_2 system on a permanent or on a stand-by basis. The Ansul SO_2 system can be started and stopped immediately; rates of flow and degrees of concentration can be changed instantly.

Ansul sulfur dioxide is also used in chlorine bleaching, in peroxide bleaching and in semi-chemical pulping. Write us for more information. ANSUL CHEMICAL COMPANY, Dept. C-47, Marinette, Wisconsin.

ANSUL

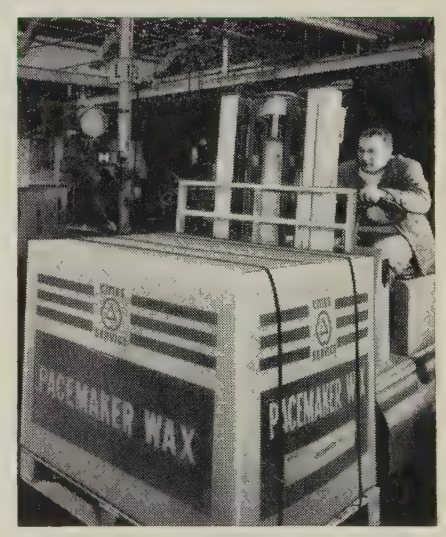
Marcal saves time, money, space with Cities Service CarTONS!

One ton units of Pacemaker Wax prove invaluable to efficient, economical operation at Marcalus Manufacturing Co., Inc., East Paterson, N. J.

The Marcalus Manufacturing Co., Inc.—better known by its trade name, Marcal—is constantly alert for new ways of reducing production costs and increasing product quality. One such method is the use of Cities Service Pacemaker Wax in unique, easily handled one ton units. Unlike other units, these carTONS, as they're called, allow simplified vertical stacking, thus enabling considerable savings in storage space. In addition, because they're one ton packages, rather than the old 100 pound type, they eliminate considerable handling time and waste disposal problems. Where Marcal formerly had 20 cartons to handle and later dispose of, there is now only one.

Marcal says further that as for the quality of the wax itself, Cities Service Pacemaker Wax ranks with the very best. Its excellent properties include high gloss and gloss retention, maximum moisture-vapor resistance, and unsurpassed blocking resistance. In view of these characteristics, coupled with excellent service, Marcal recommends Cities Service Pacemaker Wax to any user.

Your Cities Service Representative can tell you of many others who are equally satisfied, or you can write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.



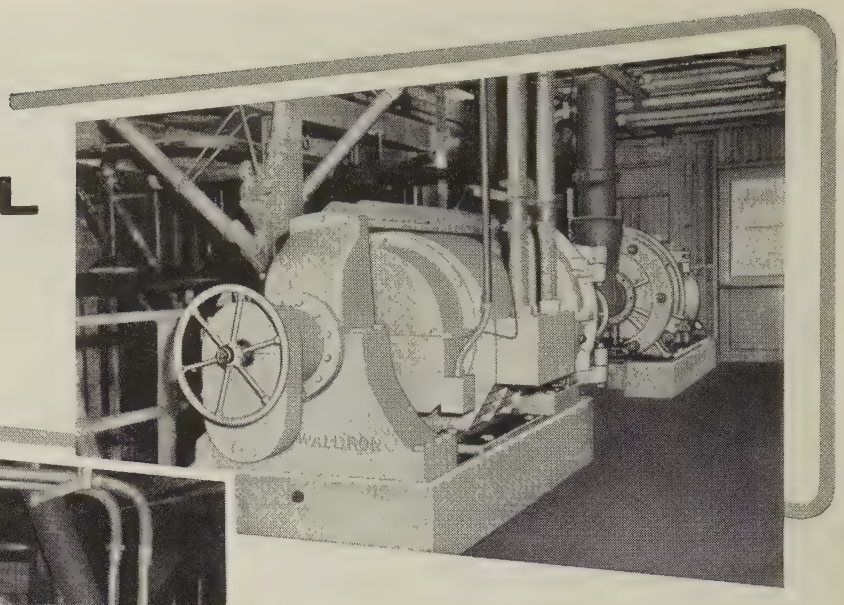
One ton carTONS of Cities Service Pacemaker Wax mean less cartons to store, less cartons to handle, less cartons to dispose of, and less man hours spent in these operations, as proved at Marcal Paper Products. In addition, Marcal feels Pacemaker is best for high gloss and gloss retention, and unsurpassed blocking resistance.

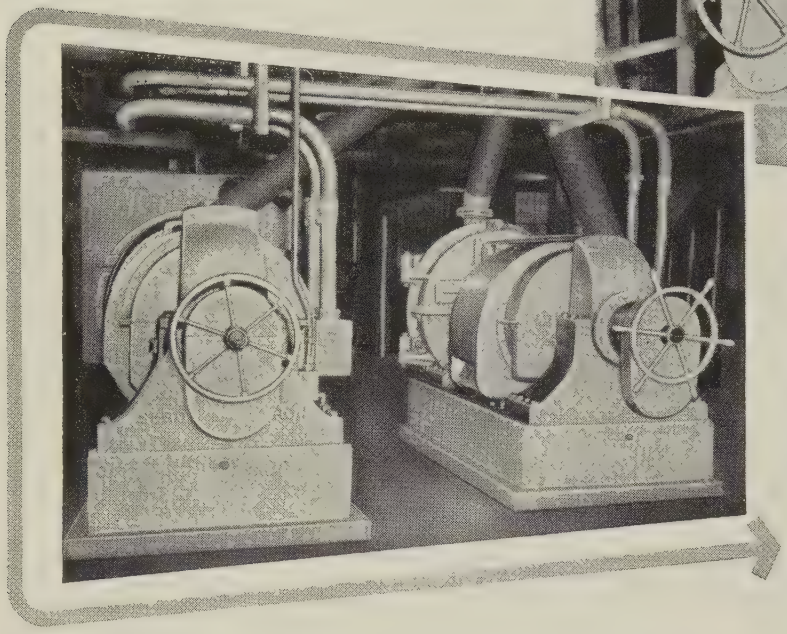
CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

for economical

SEMI-CHEMICAL

pulping...





Sonoco Products Company

repeatedly *chooses*

Sprout-Waldron Refiners

Four of the seven Sprout-Waldron Refiners installed at Sonoco Products Co., Hartsville, S. C., pulping chips for 9-point corrugating board. Two Sprout-Waldron 36-1 Refiners installed in 1939 refine waste corrugated board stock. Five Sprout-Waldron 36-2 Refiners pulp hardwood neutral sulphite semi-chemical chips in a 2-stage refining system. The five 36-2 Refiners were ordered over a nine-year period. Repeat orders are the best evidence of customer satisfaction.

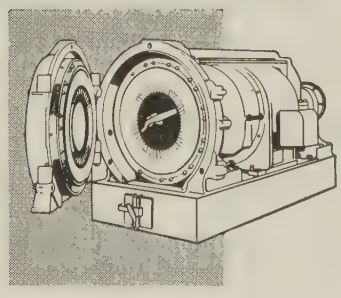
Single rotating disc design with peripheral control ring plus rugged construction for...

- **High Pulp Quality**
- **High Capacity**
- **Flexibility of Operation**
- **Low Maintenance**

The SPROUT-WALDRON refiner is the leading producer of semi-chemical pulp

For more information on semi-chemical pulping, or any other pulping application, send for our file of technical and practical data. Write to Sprout, Waldron & Co., Inc., 38 Logan St., Muncy, Pa.

S W

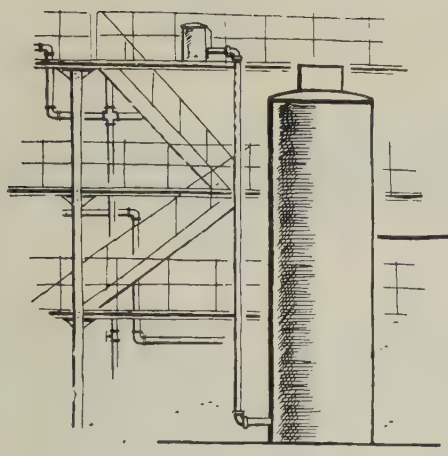


for your pulping problem—

SPROUT-WALDRON

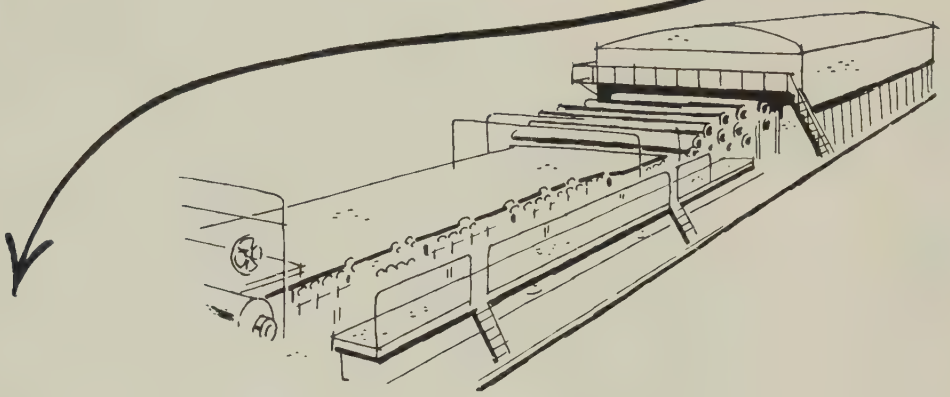
PULP REFINERS

391



FROM
KRAFT BLEACHING TOWER

THROUGH
PAPER MACHINE . . .



You get higher brightness and unmatched brightness stability with the DU PONT PEROXIDE BLEACHING PROCESS

Today's papermaking experience proves that peroxide bleached pulp retains its superior brightness—*from the pulp mill through the paper machine.*

More than a dozen mills are now using the Du Pont Peroxide Process to bleach sulfate pulp to high brightness values of 85-88 G. E. units! And there's no undue sacrifice in pulp strength!

If your mill is not already benefiting from the versatility of this inexpensive process, call or write Du Pont today. The Du Pont Peroxide Bleaching Process is easily installed and in most cases can be adapted to your needs using existing equipment.

Du Pont peroxides are available for prompt delivery from conveniently located manufacturing plants. Du Pont's modern facilities assure you a dependable supply of top-quality peroxides for your bleaching needs.

DU PONT
PEROXIDES

Albone®.....Hydrogen Peroxide
Solozone®.....Sodium Peroxide

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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Electrochemicals Dept., Peroxygen Products Div. T-6
Wilmington 98, Delaware

Please send me free booklet "Peroxide Bleaching of Sulfate Pulp."

*Name*_____

*Firm*_____ *Position*_____

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Greater production of corrugated board ...less waste

with GLOBE Corn Starch

A stronger board with excellent bond is produced when you use Globe Starch. It yields low spread figures because Globe Starch does not stick to metal, the adhesive can be run the full width of the medium, thereby reducing trim waste. When heating facilities are available, speed can usually be increased 10% to 20% over speeds used with other adhesives. Globe is preferred because ...

- *high viscosity types are available*
- *it has stable viscosity in circulation*
- *it has increased adhesiveness*

Ask our man for further details and free technical information. Write

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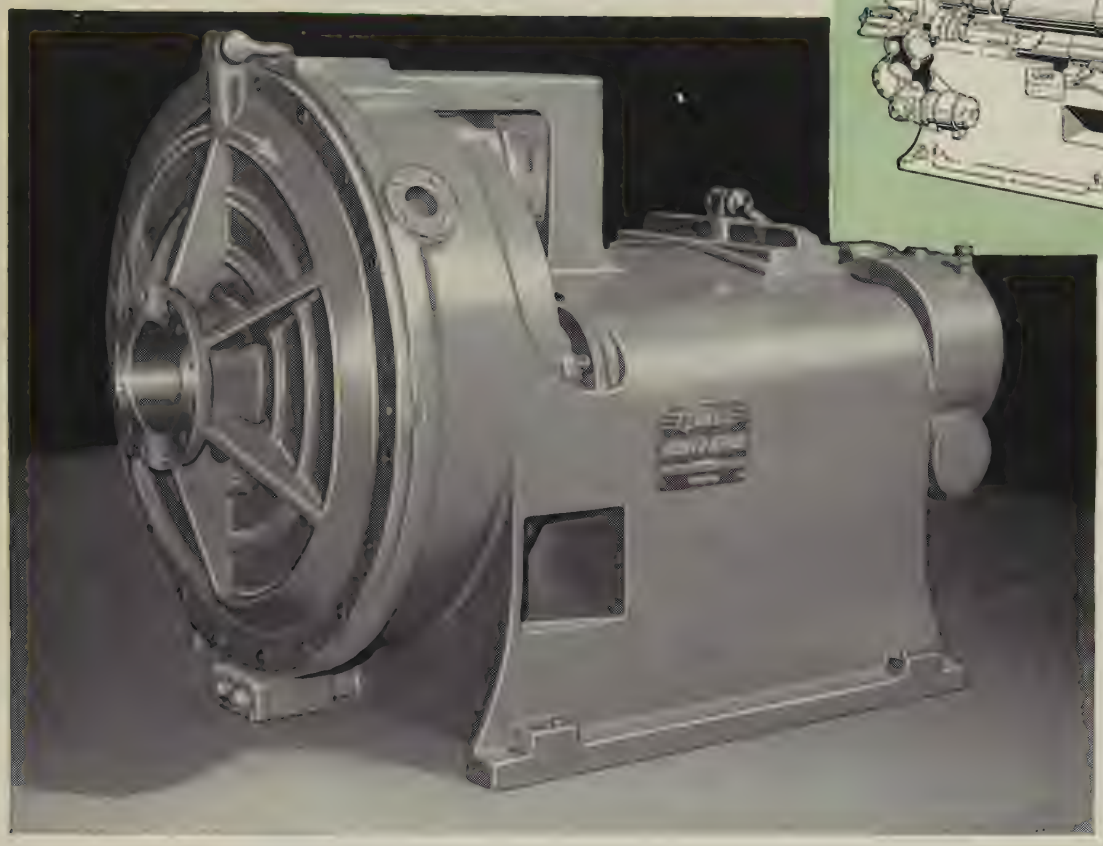
brand
CORN STARCH
"Always available"
There is a Globe Starch to meet your every need.

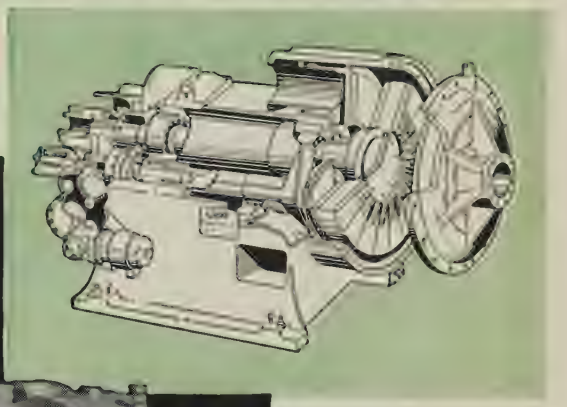
Announcing

THE NEW **Jones** **DOUBLE-D**

WITH

EQUA-FLO





This simplified drawing illustrates how stock flows around double discs, is kept under constant pressure in longer contact with refining surfaces. Fully automatic or push-button controls.

New—and it will make news in the paper industry! A fully pressurized double disc refiner that produces amazing savings in power, floor space and cost because it does the work of *two* conventional refiners.

New—but proven because full scale production models have been in operation in several leading mills for as long as 18 months.

Performance (on hard-to-work stock), simplicity of operation and ease of maintenance under mill conditions have more than lived up to experimental forecasts. Ask your Jones representative for details or write for Bulletin No. 1083.

DOUBLE

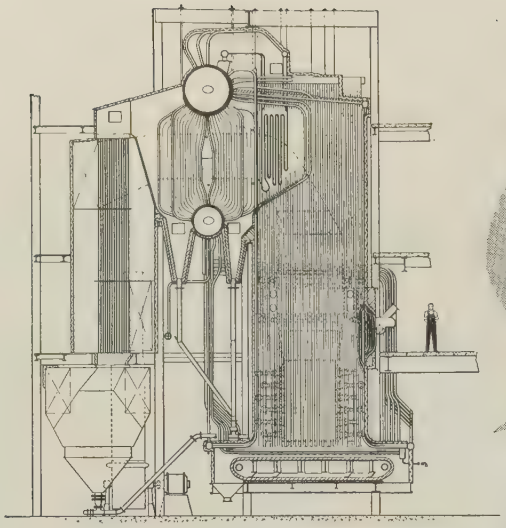
EQUA-FLO

EFFECT

E. D. Jones & Sons Company
Pittsfield, Massachusetts
BUILDERS OF QUALITY STOCK PREPARATION MACHINERY

Jones

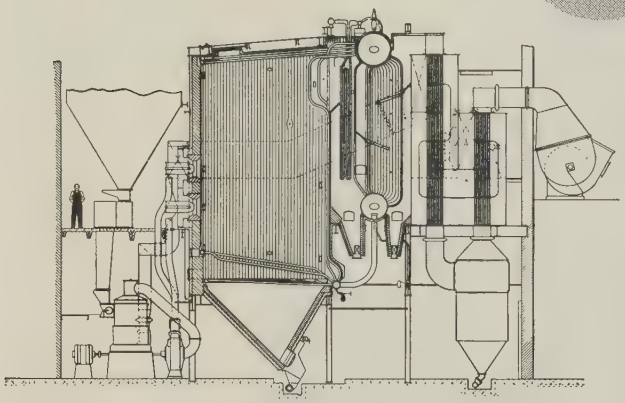
In Canada:
The Alexander Fleck, Ltd., Ottawa



Installation comprising C-E Vertical Unit Boiler, Type VU-40, equipped with C-E Bark Burning Furnace.

OVER 11,000,000 POUNDS OF STEAM PER HOUR

...that's the postwar capacity of C-E BOILERS* purchased by the Pulp and Paper Industry.



Installation comprising C-E Vertical-Unit Boiler, Type VU-50, fired by C-E Pulverized Fuel System.

Based on this 10-year sales record that includes a distinguished list of customers—just the more recent of which are shown at the left—C-E Vertical-Unit Boilers and the C-E Package Boiler (Type VP), have evidently won the seal of approval of the pulp and paper industry.

Of equal significance is the repeat order record. In this ten-year period alone, thirteen leading mills reordered VU Boilers. In fact, one leading paper company placed *seven separate orders* for VU Boilers.

The family of VU Units is versatile. It includes types especially suitable for firing with pulverized coal, oil, gas or any of these fuels in combination. Some are designed for the installation of any type of stoker. Others are equipped with the C-E Bark-Burning Furnace.

The paper industry has purchased VU and VP Units with these various types of firing in capacities ranging from 6,000 lb of steam per hr up to 300,000 lb per hr with design pressures up to 1425 psi and temperatures to 855 F.

Before you purchase any new steam generating equipment investigate the reasons for the widespread acceptance of C-E Boilers in the pulp and paper field. We'll be glad to discuss your plans with you or your consultants—without obligation of course. B-828

*Exclusive of 80 postwar C-E Recovery Units

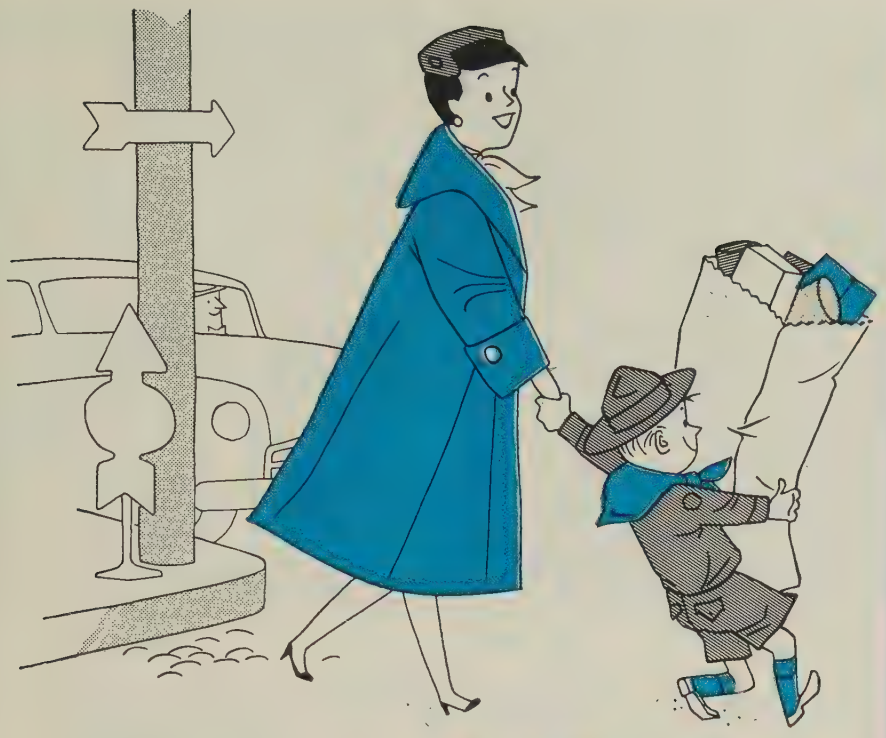
Recent Purchasers of C-E Boilers in the Pulp and Paper Industry

Albemarle Paper Company
Brown Company
Canadian International Paper Co.
Central Fibre Products Co.
Container Corp. of America
Continental Can Company
Coos Bay Pulp Corporation
Downingtown Paper Company
Finch Pruyn & Co., Inc.
Gaylord Container Corp.
Glatfelter Company, P. H.
Great Lakes Paper Co., Ltd., The
Great Northern Paper Co.
Inland Empire Paper Co.
Kalamazoo Vegetable Parchment Co.
Longview Fibre Company
Marinette Paper Company
Mead Corporation, The
Minnesota & Ontario Paper Co.
Rathborne, Hair, Ridgway Box Co.
Scott Paper Company
Valentine Pulp & Paper Co., Inc.
Waterfalls Tissue Corp.
Western Kraft Corporation
Whippany Paperboard Co., Inc.

COMBUSTION ENGINEERING

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE



a little acts BIG with LIQUID CYFOR® FORTIFIED ROSIN SIZE

You use less size—30% to 40% less—when you use Cyfor Rosin Size in place of ordinary size. So—

You save money—
Cyfor goes lots farther than ordinary size. Its results are more uniform, too.

You up quality—
Fortified Cyfor gives the hardest sizing in equal amounts. You can raise hard size specs with no increase in size.

You raise efficiency—
Liquid Cyfor adds measuring accuracy, cuts costly handling and storage. And machines run smoother with less size in the sheets.

Pound for pound, dollar for dollar, Cyfor means savings for you. So check with your Cyanamid Technical Representative today.

The Largest Variety of Paper Chemicals *to serve every industry need is offered by Cyanamid and is backed by the services of technical experts with years of practical mill experience.*

Recent Mill Developments with Cyanamid Paper Chemicals

Uniform paper coating has been attained with the use of Cynol* 770 Defoamer by an eastern mill. The Cynol is used in a clay-talc coating containing a resin binder to prevent air entrainment which would cause craters in the coating when the air bubbles break.

* * *

Excellent save-all operation with unsized papers has been reported by several mills using Accobrite® Size and alum. The ready solubility and high brightness of Accobrite result in the most efficient save-all operation.

* * *

Elimination of sticking is credited to Alwax* 253-A Size in coating formulations. At a mill using 1% of wax solids with starch in machine coating color, Alwax 253-A eliminated sticking—after dampening the sheet—on the super calender. The run was made on a bread wrap and later reports from the converting plant showed the sheet was satisfactory in every respect, including printability.

*Trade-mark

AMERICAN Cyanamid COMPANY
PAPER CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, N. Y.

Sales Offices: Boston • Charlotte • Chicago • Cleveland • Kalamazoo • Los Angeles • Mobile • New York • Philadelphia • Portland, Ore. • Seattle
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The superior quality of OK BRAND starches gives you improved tub, beater, and calender sizing. Better for coating and adhesives, too. When you make better paper at no extra cost — you've put more profit in your "paper work". Try OK BRAND and see! Discuss your special starch requirements with Hubinger's expert technicians.

the stamp of quality

OK BRAND

ESTABLISHED IN 1881

THE HUBINGER COMPANY

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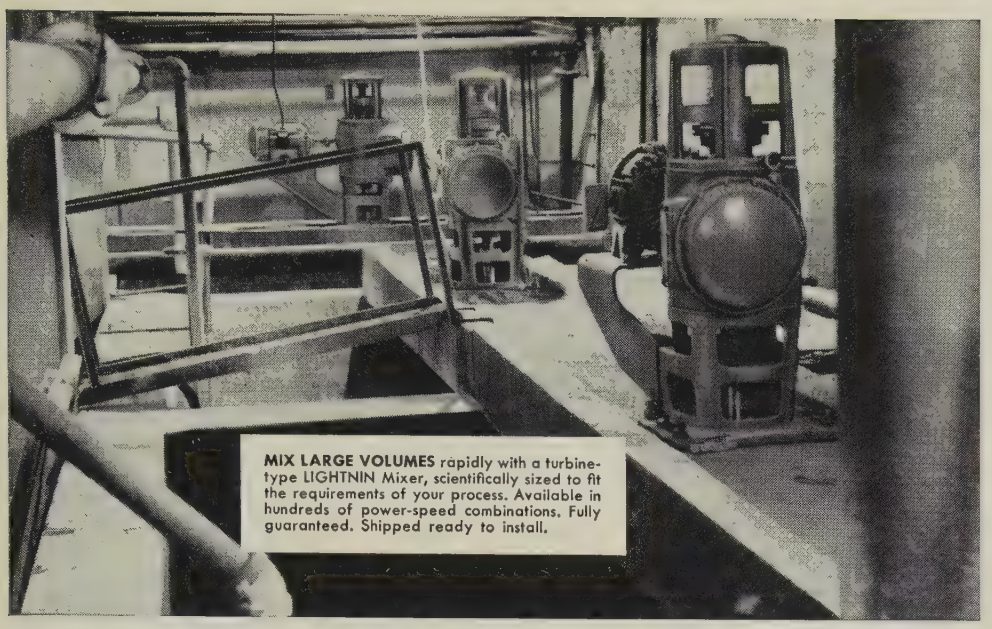
New York • Chicago • Los Angeles • Boston • Charlotte

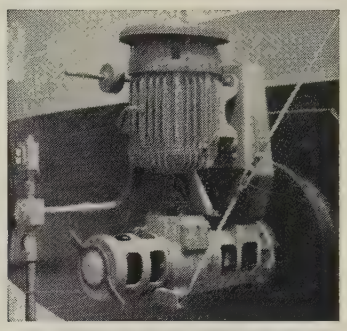
Try these top-quality starches for paper makers:

- OK BRAND Pearl
- OK BRAND E-Type Pearl
- OK BRAND Pearl 700
- OK BRAND Pre-Jel
- OK BRAND Thin Boiling Starch
- OK BRAND Oxidized Starches



MIX LARGE VOLUMES rapidly with a turbine-type LIGHTNIN Mixer, scientifically sized to fit the requirements of your process. Available in hundreds of power-speed combinations. Fully guaranteed. Shipped ready to install.

UNIFORM 6% STOCK, without costly control measures, is produced in vertical unbaffled stock chest by heavy-duty LIGHTNIN. Sizes to 500 HP.



CUT MAINTENANCE to a new low with LIGHTNIN Side Entering Mixers in rectangular chests and smelt dissolving tanks. Shut off mixer stuffing box from tank, for repacking, as simply as turning a valve. Or specify the new, fully-tested, quickly replaceable mechanical shaft seal that eliminates *all* repacking—forever!

Do your fluid mixers give you maintenance savings like these?

There are no costly maintenance headaches hiding in the tanks you see above.

Even though the shaft on the turbine-type LIGHTNIN Mixer is 12 feet long, it runs smoothly—and safely—without the nuisance and expense of a submerged steady bearing on the tank bottom.

What's more, the gears in this mixer will never need replacement because of damage caused by flexing of the overhung shaft.

Even if someone accidentally drops a heavy sack of material on the impeller while it is turning, the shock can't reach the gears. They're protected by a unique hollow-quill construction that insulates shaft from gearing.

How interchangeable parts protect you

There are no "special" parts in the mixer. It is built entirely of standard, mass-produced components, easy to replace on short notice.

If your process should ever change, you can in all probability convert your LIGHTNIN Mixer to fit the new conditions, without drastic reconstruction. Mountings, shafts, impellers are all interchangeable.

You can change even the *speed* on a turbine-type LIGHTNIN—by replacing two easy-to-get-at gears, without dismantling the unit or taking it off the tank.

What this means to you

These advantages add up to a low rate of mixer obsolescence—as well as low maintenance cost—when you mix with LIGHTNIN Mixers.

Thousands of LIGHTNINs are in service now. Hundreds have been in service 20 years and more.

For quick, competent help on any fluid mixing operation in your mill, call your LIGHTNIN Mixer representative. Or write us today.

Lightnin® Mixers

GET THESE HELPFUL FACTS ON MIXING

LIGHTNIN Catalogs contain practical data on impeller selection; sizing; best type of vessel; installation and operating hints; full description of LIGHTNIN Mixers. Yours without obligation. Check and mail coupon today.

MIXCO
fluid mixing specialists

- ☐ DH-50 Laboratory Mixers
- ☐ DH-51 Explosionproof Laboratory Mixers
- ☐ B-102 Top Entering Mixers (turbine and paddle types)
- ☐ B-103 Top Entering Mixers (propeller type)
- ☐ B-104 Side Entering Mixers
- ☐ B-106 Condensed Catalog (complete line)
- ☐ B-107 Mixing Data Sheet
- ☐ B-108 Portable Mixers (electric and air driven)

MIXING EQUIPMENT Co., Inc.
142-f Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd.
100 Miranda Avenue, Toronto 10, Ont.

Please send me, without obligation, catalogs checked at left.

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Company_____

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City_____ Zone_____ State_____

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UNIFORMITY
STABILITY

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UNION SALES CORPORATION

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In back of your TV Set is a RICE BARTON papermaking machine!

Good reception in your television set is dependent upon a combination of the papermaker's skill and precision machinery. Rice Barton papermaking machines, in skillful hands, produce condenser tissues .0002" thick with tolerances measured in hundred thousandths.

Rice Barton machines will make paper to meet your most exacting requirements.

RB6-55

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Paper Machine Builders Since 1837

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it may help you!

Titanium is a metal the world has known for a long time—and now you can put its unusual combination of valuable properties to work for you in the form of Carpenter Titanium Tubing.

It's light. It's strong. It has a remarkable endurance limit. Weighing about 56% as much as high alloy steel, titanium has a tensile strength that compares favorably with many steels. It possesses an endurance ratio well above both steel and non-ferrous metals.

Carpenter Titanium Tubing is highly resistant to most corrosives, salt water and salt atmospheres. Its extreme resistance to erosion and cavitation is unique among metals. Yet, with all this, Carpenter Titanium Tubing is ductile, may be successfully machined.

With all these desirable characteristics—in combination—it may be that Carpenter Titanium Tubing can help you solve a number of design and production problems.

If you would like more information about Carpenter Titanium Tubing, and its place in your product or plant, write today to:

MEMBER FORMED STEEL TUBE INSTITUTE

The Carpenter Steel Company,
Alloy Tube Division, Union, N.J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y. "CARSTEELCO"

Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

Du Pont
PAPER WHITE BN
for truly distinguished white paper...
paper that's WHITER than WHITE

You see it here! This entire page of Bright White paper was dyed with Du Pont Paper White BN. Compare this paper with the whitest paper in your line. You'll see the difference!

There's a look of highest quality in either bond or printing paper that's dazzling white. Letterheads are sharper, printing is clearer, colors look brighter. Yes, the most distinguished paper you can produce is paper made *whiter* with Du Pont Paper White BN!

We'll be glad to give you further information and technical assistance. Just write to: E. I. du Pont de Nemours & Co. (Inc.), Dyes and Chemicals Division, Wilmington 98, Delaware.

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Better Things for Better Living . . . *through Chemistry*

Death *takes a holiday...*

let's make it a PERMANENT VACATION!

Vital living forests in place of stagnant acres...control of deadly forest fires and their terrible consequences: Death must take a permanent vacation from America's forest lands

Great progress has been made in protecting timber lands against fires since Weyerhaeuser initiated the Tree Farm movement in 1941 by establishing the Clemons Tree Farm. Weyerhaeuser rules call for vigorous protective measures not only against fires, but against forest insects and diseases as well.

At least 170 thousand forest fires nonetheless get started each year throughout the country; these avoidable fires lay horrible waste to about 15,000,000 forest acres annually.

Nine out of ten forest fires are preventable: they are man-caused and spring from public carelessness and ignorance. Thus, public education and Tree Farm organization will help prevent future forest fires.

Perpetual tree production plus the scientific control of fires assure woodpulp consumers of a constant supply from Weyerhaeuser.

PULP DIVISION

WEYERHAEUSER

Insect Resistant Packaging

The Background of the Problem

WILLIS M. VAN HORN

This discussion is general in nature and is designed to describe the problem and give background information helpful in understanding the other papers on the symposium.

NONE will doubt the tremendous influence that insects exert on the life and activities of man. This comes about because man and some insects want the same thing at the same time. Man is, therefore, engaged in a life-long battle—first to create what he needs and second to protect it so that he can realize on the fruits of his work. It is easy to underestimate the importance of our insect adversaries, and it is also dangerous. These creatures are all about us, more or less like air. They help themselves to our food, they become unwelcome guests in our homes and factories, they eat our clothing and even our homes, they may carry disease to us, or they may affect us in many other ways.

The primary requisite of any living creature is food. Man goes to a lot of trouble and work to get his supply. In the past few years great advances have been made in growing, processing and, particularly, in packaging food. This group does not need to be told what an important part paper and paper products have played in these developments.

It might be assumed that, once having grown, processed, and packaged his food, man might feel that it would be relatively safe from insect damage. That this is not always the case is the reason for this symposium.

One may well ask what are our most important insect enemies when it comes to packaging. There are many. There are such species as cockroaches, silverfish, fire brats, and the like. Some of our greatest troubles, however, come from those forms which have the capacity to bore through or penetrate a package. In this category are found the cereal and dried fruit infesting species. In general, these species fall into two classifications—the beetles and the lepidopterans.

These forms live a life cycle of four stages, a condition that the entomologist calls "complete metamorphosis." The eggs are laid by an adult insect and develop into wormlike mobile larvae; these, after a certain period pass through a period of pupation, and from the pupa the adult emerges. In many cases, it is while the insect is in the larval stage that it does the most damage. The larva cannot reproduce, it can only eat and grow.

It might be of interest to examine in some detail some of the insects which are of particular interest to those interested in packaging dried food.

One of the most vigorous, but fortunately not the most common of these insects is a beetle called the cadelle (*Tenebroides mauritanicus*). The adult beetle is black, from $^1/_3$ to $^1/_2$ in. in length, and its head and thorax are distinctly separated from the rest of its body. It feeds upon cereal products especially. Its eggs are laid on or near food, perhaps in cracks, or even under the flaps of a carton. They develop into gray soft-bodied larvae which may grow to more than $^1/_2$ in. in length. The important feature of these larvae are their very powerful mandibles or chewing apparatus. With these they are able to penetrate metal foil of considerable thickness. On one occasion one of these larvae was observed to chew its way into a slate top of a laboratory desk. These larvae may complete their development in 70 days under favorable conditions, or they may take longer.

One of the commonest insect pests that thrive on cereal products is the confused flour beetle or bran bug (*Tribolium confusum*). It has a less ubiquitous cousin, the red flour beetle (*Tribolium castaneum*). The habits of these two are much the same so what is said for the confused flour beetle can also be said for the red variety. The adult beetle is about $^1/_7$ of an inch long and it feeds on all kinds of grain, flour, starchy materials, beans, peas, ginger, dried plant roots, dried fruits, nuts, chocolate, drugs, cayenne pepper, and many other foods. The eggs are laid in crevices and cracks, and they develop into brownish white larvae which may grow to be a quarter of an inch in length. These larvae feed voraciously and may pupate after a week or 10 days. Under optimum conditions a generation may pass in as little as 1 month. Adults may live as long as 2 years.

Another rather common cereal-attacking insect are the grain borers, the lesser (*Rhyzopertha dominica*) and and the larger (*Dinoderus truncatus*). Of these two the lesser grain borer is much more widely distributed. It feeds, in both the adult and larval stages, on the insides of grains and seeds. The adults are brown to black and are about $^1/_8$ in. long. The head is held in a downward position and is, therefore, quite hard to see from above. A generation may be completed in a month.

The saw-toothed grain beetle (*Oryzaephilus surinamensis*) is noted for its ability to penetrate small apertures such as may be found at package closures. It gets its name from the fact that the outside edges of its thorax are serrated. This insect feeds on most all types of cereal products as well as dried fruits, nuts, yeast, sugar, candy, tobacco, and other materials. The adults are about $^1/_{10}$ in. long, are very slender and flattened top-to-bottom-wise. The larvae have brown heads, are otherwise white, and have tapering abdomens. They grow to be about $^1/_8$ in. in length. The life cycle takes about 30 days.

There are three common insect pests of the moth type—the Angoumois grain moth (*Sitotroga cerealella*),

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the Mediterranean flour moth (*Ephestia kukniella*), and the Indian meal moth (*Plodia interpunctella*).

The grain moth does much of its damage while the grain is in the field or processing plant. Only occasionally does it find its way into cereal products already packaged.

The flour moth causes a great deal of trouble in flour mills, but it will also attack breakfast foods. The adult moth is a pale gray color from $^1/_4$ to $^1/_2$ in. in length. The eggs are laid in and around food in cracks or crevices. The caterpillars spin silken webs and these are largely responsible for food spoilage. When full grown the caterpillars are about $^1/_2$ to $^3/_5$ in. long, pinkish in color. The entire life cycle may take 10 weeks.

The meal moth attacks all kinds of grains, and cereal products among other things. The adult moth is about $^1/_2$ to $^3/_4$ in. in length. The caterpillars are white and often have a greenish or pink tinge. The life cycle may be passed in 30 days.

Generally speaking it can be stated that as far as the problem of packaging is concerned, the beetles are more troublesome than the moths, simply because they and their larvae are more often equipped with mouth parts which enable them to bore through fiber sheets.

At this point, it might be well to review briefly some of the observations made on insect penetration of packages, and some of the efforts made to render packages insect resistant.

There are, in general, two ways by which fiber packages may be rendered insect resistant.

The first of these is to provide a physical barrier between the insect and the contents of the package. In a sense, the fiber package itself, if thick enough, affords such a barrier, and while it may minimize insect infestation, it is not likely to be absolutely insectproof. It has been shown that if the package is constructed in such a way that the outer or exposed surface is smooth, with a minimum of cracks, folds, seams, or creases the incidence of insect penetration is greatly reduced. However, such packages are still vulnerable to the strong borers, such as the cadelle. Attempts have been made to reinforce the fiber container with such materials as metal foil or sodium silicate. The greatest problem associated with the physical barrier method is the nature of the package closure. It has been observed, for example, that the larvae of the Indian meal moth and of the confused flour beetle can pass through apertures which are only 0.12 mm. in width. Saw-toothed grain beetle larvae have been observed to pass through crevices 0.16 mm. in width. These distances impose rather severe conditions on package closures, at least under present conditions of closure technology. In general, therefore, it has become apparent that the physical barrier method of rendering packages insect resistant presents difficulties.

For that reason package manufacturers seem to have turned more and more to a second method—that of providing a chemical barrier between the outside of the package and its contents.

In view of the fact that the remaining papers on this symposium are devoted to the problem of applying such chemical barriers, it will serve no useful purpose to discuss it further now.

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The Status of Federal Research on the Development of Insect-Resistant Packages

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The cooperative research study between the U. S. Department of Agriculture and the Quartermaster Corps in the development of insect-resistant packaging which has been under way at the Stored-Product Insects Laboratory, Savannah, Ga., since 1950 has developed a sound appreciation of the important factors which influenced the improvement of packaging to this end. The study today has shown that: (1) paper bags appear to offer excellent possibilities for adaptation to insectproofing and from 9 to 12 months' protection can be expected with multiwalled paper bags having a synergerized pyrethrum treatment applied on the outside ply; (2) lindane and methoxychlor appear to show great promise for possible use as protective coatings; (3) more effective insecticide treatments will have to be found if textile bags are to be made insectproof for periods extending over 6 months; (4) insecticide treatments on paper shipping boxes are not sufficiently effective to prevent insects from entering the package if open seams are present; to overcome this it is necessary to develop either boxes which are structurally more resistant to insect entrance or more effective insecticide coatings; (5) needle punctures on paper bags must be overtaped in order to obtain complete exclusion of insects and to derive the maximum benefits from insecticide treatments applied to the bags; (6) sleeve valves are an important mode of entry for insects and it may be possible to design more effective folds for the sleeves to limit insect entrance; (7) the deposit of pyrethrum-piperonyl butoxide deteriorates rapidly when exposed to warehouse conditions but to a much less degree on rolled paper stored in darkness; (8) the greater part of the protection provided by the pyrethrum-piperonyl butoxide treatment can be explained on the basis of repellency rather than toxicity; (9) there exist several possibilities for the improvement of the effectiveness and duration of the pyrethrum-piperonyl butoxide treatment through the use of compounds which activate or extend the activity of the treatment; (10) it may be possible to substitute effective repellents in place of the pyrethrum treatment to accomplish the same end since the protection provided by synergized pyrethrum appears to be based on the fact that it repels stored-product insects.

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The problem of insects infesting packaged foods is an old one as well as a very costly one. The importance of this problem became most noticeable during World War II when food conservation was most necessary. At that time the problem was considerably magnified by the practice of storing large quantities of foods for the armed forces, our allies, and for the civilian population.

During the early days of the war a group was organized under the direction of E. O. Essig in the Division of Entomology and Parasitology, University of California, to investigate various phases related to the insect infestation of stored foods. One of the very important findings of Essig *et al.* (*1*) was that one or more of the stored-product insects will penetrate practically any package made of textile or paper products. If low cost containers were to be used, there was no alternative but to improve the insectproofness of textile and paper containers either by the use of chemicals or by improving the physical structure of the package. The general trend in the development of insect-resistant packages has been toward the use of chemicals.

In 1945 a number of investigators tested the effectiveness of certain repellents and toxicants. Synergised pyrethrum was one of the most promising materials to emerge from these preliminary investigations. Cotton, Frankenfeld, and Strickland (*2*) and Gray (*3*) reported good results with mixtures of pyrethrum and piperonyl butoxide when applied to textile bags.

The Research and Development Division, Office of the Quartermaster General, U. S. Army, became interested in these findings and requested the Savannah laboratory to conduct semipractical field tests on the effectiveness of synergized pyrethrum, or other insecticides, when applied as coatings on both textile and multiwalled paper bags. When this work was first started in Savannah, it was entirely supported by military funds. From the very beginning, however, the interest shown by various industries was so great and the requests for information so numerous that it was necessary to investigate the civilian aspects of this problem as well. This work was done with funds appropriated by Congress to the Department of Agriculture. As the specific military phases of the project were completed, military funds were withdrawn to the extent that the bulk of the research on insect-resistant packages now being conducted at Savannah is with Department of Agriculture funds.

The research that has been done to date is too voluminous to discuss here in detail. Therefore, the discussion will be limited to a brief summary of the more important findings. These will be discussed under appropriate headings. Several manuscripts are being prepared for publication which will fully describe the tests summarized here. References are made to these manuscripts when the results are mentioned.

INSECTICIDAL COATINGS

As previously mentioned, the first tests conducted at Savannah on protective packages were at the request of R&D Division, OQMG. These were to determine the effectiveness of several insecticides when used as coatings on 50-lb. flour bags of muslin, three-ply paper, and corrugated paper shipping boxes. The insecticides which were evaluated were synergized pyrethrum, synergized allethrin, lindane, and methoxychlor. The first series of tests with muslin and paper bags was started August, 1950. A second series was conducted when it was found that the insecticide coatings on the paper bags used in the original test were not uniform. The latter was started October, 1951, and terminated April, 1953. These are believed to have been the first controlled large-scale tests on the evaluation of insecticide-treated bags. Approximately 15 tons of flour were used in each of the two series of tests mentioned above.

The tests with the treated corrugated paper shipping boxes were started March, 1952, and completed September, 1953.

Muslin Bags

The results with the treated muslin flour bags were very discouraging (Davis and Laudani (*4*)). As shown in Table I, all of the treatments failed in less than 6 months. These were not in agreement with the results obtained by Cotton *et al.* (*2*) or Gray (*3*). Since the muslin bags treated with synergized pyrethrum used in the tests described were prepared identically with those used by Cotton *et al.* in Kansas, or Gray in Canada, it is believed that the difference in climatic conditions may have been responsible for the difference in the results obtained. This point should be kept in mind in future tests with pyrethrum coatings for it has been well established that certain climatological factors do hasten the disappearance of pyrethrum. The results strongly indicate that more effective insecticide treatments will have to be found if textile bags are to be made insectproof for periods extending over 6 months.

Paper Bags

The results with the multiwalled paper bags, however, were very encouraging (Table II). These tests definitely showed that synergized pyrethrum coatings on paper bags were effective in preventing insect infestation up to 12 months. These tests also showed that, with proper dosages, allethrin and methoxychlor rendered as good, and lindane better, protection than was obtained with pyrethrum.

Other studies conducted at Savannah showed that all of these insecticides migrated through the inner plies of the paper bags into the flour. Butterfield, Parkin, and Gale (*5*) reported similar findings on the transfer of DDT applied to burlap bags. It has been felt that because of this migratory action methoxychlor and lindane could not be recommmended for use on food packages until residue tolerances had been established

Table I. Approximate Duration of Effectiveness of the Various Treatments Tested on Muslin Flour Bags

Duration of protection,[a] months	*Insecticide treatment*	*Intended rate of application, mg./sq. ft.*
3 to 6	Pyrethrum + piperonyl butoxide	5–50
	Pyrethrum + sulphoxide	5–50
	Allethrin + sulphoxide	7.5–75
0 to 3	Methoxychlor	200
	Methoxychlor	100
	Lindane	25
	None (controls)	...

[a] A treatment was considered to have lost its effectiveness when more than one penetration occurred in a bag, or there was a sudden increase in the insect population in the contents.

Table II. Approximate Duration of Effectiveness of Various Insecticides in Clay Coatings on Three-Ply Paper Bags

Duration of protection, months	*Insecticide treatment*	*Intended rate of application, mg./sq. ft.*
12 to 15	Lindane	25
9 to 12	Methoxychlor	100
	Methoxychlor	200
	Pyrethrum + piperonyl butoxide	5–50
	Pyrethrum + sulphoxide	5–50
	Allethrin + sulphoxide	7.5–75
0 to 6	None (controls)	...

by the Food and Drug Administration. With the enactment of the Miller Bill (Public Law No. 518), there is a possibility that a tolerance can be established for insecticidal residues in flour and other foods which should be packed in insecticide-coated packages. If a tolerance on these foods is set comparable to that which has been discussed for fruit and vegetables (*6*), then it may be possible to use methoxychlor and lindane along with pyrethrum for insectproofing packages.

Paper Shipping Boxes

Two series of field tests were conducted with insecticide-coated, corrugated paper shipping boxes. The results were very conclusive: neither pyrethrum, allethrin, methoxychlor, nor lindane was effective when a package contained one or more open seams. Only those packages which had all the seams taped remained free of insects. With complete sealing, however, almost as good protection was obtained with the untreated boxes as with the treated boxes. Since it is both difficult and costly to completely tape all seams of a shipping box, the development of an economical, insectproof shipping box is one of the most challenging phases of the work under discussion. This challenge is not only to those working on the entomological aspect of the problem but also to the packaging engineers. The entomologists will have to come up with a more effective treatment than we have now, or the packaging engineer will have to come up with a box which in itself is more insectproof, or with a more economical method of efficiently sealing all closures.

IMPORTANCE OF GOOD PACKAGE CONSTRUCTION

Proper construction is necessary with bags as well as with shipping boxes if maximum protection is to be obtained for the insecticide coatings. The studies have shown that an insecticide treatment is only as good as the construction of the package. This is in agreement with Gray (*3*) who made this statement: "Chemical treatments can add to the resistance of package materials. They cannot act, however, as substitutes for a well-designed, smooth, properly sealed, and durable container."

Table III. The Comparative Duration of Effectiveness of Pyrethrum-Piperonyl Butoxide Treatments on Various Types of Bags

Type of bag	*Pyrethrum, mg./sq. ft.*	*Piperonyl butoxide, mg./sq. ft.*	*Duration of effectiveness, months*
Burlap	10	100	0–3
Muslin	5	50	3–6
Jute (heavy and tightly woven)	[a]	90	9–12
Multiwalled paper	5	50	9–12

[a] Pyrethrum present but amount unknown.

Comparative Insectproofness of Various Types of Bag Materials

Many workers in this field agree that there are only two or possibly three major insects which will penetrate packages and thus infest their contents. The majority of the stored-product insects depend on a mode of entrance being present to reach the packaged food. It should be further emphasized that these few penetrating species are less common and fewer in number than those in the other group. It is easily seen, therefore, that mechanical exclusion is most essential. The relationship between construction and protection induced by insecticide coatings can be readily seen in the comparative results shown in Table III with various types of bags: the looser the construction, the shorter the period of protection rendered by the treatment.

The above shows very definitely that the multiwalled paper bags are more adaptable for insectproofing than textile bags. However, the mere fact that a bag is multiwalled and made of paper is not sufficient to make it a good insect-resistant bag. Needle punctures, bad valve closures, and broken seams all serve to lessen the mechanical resistance naturally possessed by paper bags.

To determine the relationships between certain structural features of paper bags and insect infestation, several differently constructed bags were exposed in a room infested with only flour beetles. Since this species can gain entrance only if a mode of entry is present, the number of insects found inside the bags after a period of exposure were an indication of the lack of resistance to insects of the particular structural feature being investigated.

Needle Punctures

One test was made to study the importance of needle punctures as points of entry. On three of the bags, tape was applied over the needle punctures; no tape being applied over the punctures in the other three bags. The sleeve valves on all of the bags were sealed and taped to prevent entry at this point. All of the bags were exposed for 9 months to flour beetle infestation, after which they were removed and the number of insects in the flour determined. The results are shown in Table IV. The average number of insects in the bags on which the needle punctures were not taped was nearly five times that in the bags on which the punctures were taped.

Closures

The importance of a good closure of the sleeve valve on valve-type bags may be demonstrated with the results of a test conducted to determine if a more effective method of folding the sleeve valve could be found. Two sleeve-valve bags were filled with flour and the

Table IV. Average Number of Flour Beetles per Bag Having Needle Punctures Taped and Untaped After an Exposure of 9 Months

Condition	*Larvae*	*Adults*	*Total*
Needle punctures taped	0.3	5.3	5.7
Needle punctures not taped	21.3	5.7	27.0

Table V. Average Number of Flour Beetles Found in Each Sleeve-Valve and Open-Mouth Bag After an Exposure of 3 to 18 Months

Type of bag	Number of insects, exposure period, months						Average per bag
	3	6	9	12	15	18	
Sleeve-valve	5	3	10	76	19,320	12,469	1329
Open-mouth	2	2	7	16	179	6,414	276

valves folded in the usual manner. Two other sleeve-valve bags were filled and the valves folded in a special manner consisting of a series of triangular folds. All four bags were exposed to a flour beetle infestation for 1 month after which the number of insects in the flour was determined. A total of 24 flour beetles was found in the bags on which the normal fold was used, whereas, only 1 insect was found in the two bags having the experimental fold. This preliminary information points out two factors: (1) the sleeve valve is an important mode of entry, and (2) it may be possible to develop a more effective valve in respect to entrance by insects.

It has been observed in tests which included both sleeve-valve bags and open-mouth bags that the former was more susceptible to insect infestation. Table V shows data from a series of tests conducted over a period of 18 months. Included in the tests were two series of treated bags which were identical in all respects except that one series consisted of sleeve-valve bags while the other consisted of open-mouth bags. The figures shown are the total number of insects found in each series of four bags after successive 3-month storage periods. These data show that the total infestation was greater and infestation occurred earlier in the sleeve-valve bags than in open-mouth bags.

RATE OF DISAPPEARANCE OF SYNERGIZED PYRETHRUM COATINGS

Results of chemical analyses conducted with treated paper taken from bags exposed under warehouse conditions showed a marked decrease in the level of insecticide deposit as the treatment aged (Table VI). These results were obtained with three-ply, 50-lb. bags having commercially applied pyrethrum-piperonyl butoxide coating on the outer ply. The pyrethrum deposit of 6 mg. per sq. ft. dropped to 1 mg. at 9 months and to 0.3 at 18 months. The last mentioned figure is below the sensitivity of the Cueto and Dale (*8*) analytical method which was used in the determinations and, therefore, the presence of any pyrethrum at the 18-month exposure might be questionable. The Jones, Ackerman, and Webster (*9*) method of analysis was used for piperonyl butoxide.

At the time the above analyses were made, samples were also analyzed from the original roll of paper which had been stored in a dark closet during the course of the tests. Under these storage conditions, the level of the pyrethrum and piperonyl butoxide did not drop as much as that of the paper exposed under warehouse conditions.

The rate of disappearance of both materials was considerably more rapid in both types of storage than indicated by Incho, Incho, and Matthews (*7*). Their work indicated the deposits to be of the same level after aging 1 year as they were when aged less than one month. During the tests, these workers stored the treated papers in darkness between sheets of aluminum foil. Undoubtedly, the difference in the rate of disappearance was due largely to the method of storage during the aging period. Since the treated papers were stored under more practical conditions at Savannah than by Incho *et al.*, it must be assumed that the rate of disappearance of pyrethrum and piperonyl butoxide will be quite rapid as was the case with the treated papers exposed at the Savannah laboratory.

Table VI. Chemical Analyses of Kraft Paper Samples Taken from a Roll Which Was Stored in Darkness and from Paper Bags Made of Paper from the Roll and Stored Under Simulated Warehouse Conditions

Figures shown are expressed as mg per square foot of pyrethrum (Pyr.) and piperonyl butoxide (PB)

Origin of sample	Storage period, months							
	0		3		9		18	
	Pyr.	PB	Pyr.	PB	Pyr.	PB	Pyr.	PB
Roll	6.0	...	3.6	33.2	3.9	20.8	1.5	18.2
Bags	6.0	...	2.6	...	1.0	2.2	0.3	4.0

TOXICITY VERSUS REPELLENCY OF PYRETHRUM

In laboratory and semipractical tests conducted concurrently with the same samples in several tests, it was demonstrated that the protection against infestation provided by the pyrethrum-piperonyl butoxide treatment was mostly due to the repellent action of the insecticide coating and not to toxicity. Table VII shows the results of laboratory toxicity and repellency tests which were conducted with samples taken from treated bags when a field test was first started and again 3 and 9 months later. The initial knockdown produced by the treated paper was 75 to 85% but this dropped to 0 to 18% after 3 months' exposure and to 0 after 9 months' exposure. On the other hand, the repellency produced by the treated paper remained high throughout the entire 9 months. It is interesting to note that the bags from which the paper used in the above tests were taken gave perfect protection during the entire 9-month period. Since the toxicity disappeared after 3 months, but the repellency lasted the entire period of protection, this effectively demonstrated that repellency was the more important factor.

The toxicity tests were conducted in much the same manner as the "surface activity" tests described by Incho (*7*) and the repellency tests were conducted according to the technique described by Laudani, Davis, and Swank (*10*).

The conditions observed under warehouse storage also indicated very strongly that the mode of action of synergized pyrethrum coatings was by repellency. Although as many as 168 treated bags were present in the room, the insect infestation present not only persisted during the 9 months but the population actually increased. Even with this increase in insect population, however, as mentioned above, protection against infestation was obtained during the 9 months' storage period.

Table VII. The Action Produced on Flour Beetle Adults in Laboratory Tests by Samples of Treated Kraft Paper Taken from Bags Exposed Under Warehouse Conditions

Type of action	Exposure period, months					
	0		3		9	
	A	B	A	B	A	B
Knockdown	75	85	0	18	0	0
Repellency[a]	80	76	85	73	61	61

[a] Per cent of insects counted on untreated half of a circular arena.

WORK IN PROGRESS AND FUTURE PLANS

From the preceding discussion, it is evident that a great deal of research remains to be done if a satisfactory means of protecting all packaged foods against insect infestation is to be realized. The demand for insect-resistant packages by the general public, by the food processing industry, by the food packaging and storage industry, and also by the paper industry has emphasized the necessity of expanding the research program on the development of insect-resistant packages.

An important part of the program is directed toward the improvement of pyrethrum coatings. In this study laboratory and small-scale semipractical tests are used to evaluate the effectiveness of experimental compounds in activating or extending the action of the pyrethrum. Several promising leads have been found and further practical tests are now in progress.

Another part of the research program is directed toward a search for other repellent materials less expensive and longer lasting than pyrethrum. It has been suggested that a repellent may be of greater value than a toxic material in preventing invasion of packages by insects. A large number of candidate repellent compounds have been evaluated and approximately ten have been found which appear promising. Advanced evaluation tests are now in progress with these compounds.

Other insecticides are being evaluated as package treatments. Fourteen selected insecticides have been evaluated and of this group lindane and methoxychlor appear to be very promising. Davis and Laudani (*4*) have described large-sale, semipractical tests which included treatments of these insecticides on three-ply paper bags and presented results which indicated that longer protection was obtained with lindane-treated bags than with bags treated with pyrethrum-piperonyl butoxide.

Plans have been made to determine by chemical analyses the amount of insecticide migration which takes place when methoxychlor and lindane coatings are used on the outer ply of multiwalled paper bags. In conjunction with this study, it is planned to investigate chemical and physical means of preventing the migration of insecticides into the packages.

The advancement made in these studies has been possible only because of the fine cooperation given the Savannah laboratory by the bag and box industry as well as by various food packaging firms. The number of inquiries received and the interest shown by potential users of insect-resistant packages has been most gratifying. It has also been very encouraging to learn that not only manufacturers of human foods but also manufacturers of animal foods are interested in insectproof packages. A low-cost, well-constructed, insecticide-coated package will be a great accomplishment and truly a great food saver. The development of insect-resistant packages will continue to be a major project at the Savannah station, and the continued cooperation of industry will be needed to solve this problem at the earliest possible time.

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Insect Repellent Coatings for Multiwall Paper Bags

K. A. ARNOLD

Shortly after World War II the St. Regis Paper Co. became interested in the development of multiwall bags impervious to penetration by insects, especially those in flour. After extensive laboratory investigation Pyrenone was found to be particularly effective, when applied to paper surfaces. Permission was granted by the U. S. Pure Food and Drug Commission for use on flour bags. Field tests conducted by two flour milling companies confirmed the laboratory results.

Due to insect infestation, millions of dollars worth of food products have been condemned as unfit for human consumption by Federal inspectors. In flour products, the main sources of infestation appear to be in the grain, during the milling process, and through the package during the shipping and storage. Considerable progress has been made in treating the grain with nontoxic insecticides to prevent infestation at that point. Shortly after World War II an accelerated program of sanitation in the mills promised to eliminate infestation at that stage. Early in 1946, St. Regis became aware of a definite need for the development of a multiwall paper bag completely impervious to penetration by the flour infesting insects, especially

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for shipment of flour into hot, humid areas favorable to breeding of insects.

LABORATORY TESTS AND EARLY DEVELOPMENT WORK

Insects occurring most frequently in flour infestation include the cadelle, saw-toothed grain beetle, confused flour beetle, and the lesser grain borer. Tests on commercial 100-lb. flour bags in 1946 proved that the regular untreated multiwall paper bags were fairly resistant to insect penetration under normal conditions and greatly superior to untreated fabric bags. Under severe infestation conditions, such as are encountered in the southern states and tropical regions, the untreated multiwall bag may be penetrated by the flour infesting insects. For this reason, laboratory tests were started to determine the effectiveness of various insecticides against the infesting insects. After extensive laboratory evaluations Pyrenone was found to be far more effective than other insecticides against flour infesting insects, under the conditions of treatments adaptable to multiwall bags. Pyrenone is a combination of two insecticides and is made up in the ratio of 10 parts piperonyl butoxide to 1 part pyrethrin. The piperonyl butoxide acts as a stabilizer and activator for the pyrethrin content. Laboratory tests indicated this ratio to be optimum and that a coverage of 50 mg. piperonyl butoxide per sq. ft. plus 5 mg. pyrethrin per sq. ft. was needed for effective protection against insect penetration.

LABORATORY TESTS ON FULL SIZE COMMERCIALLY TREATED BAGS

After it was determined that Pyrenone looked very promising and the coverage needed for protection, extensive tests were made to determine a suitable formulation to treat paper on the paper machine. Since it was not known whether a surface coating or impregnation of paper would give the best results, both type treatments were applied by commercial machines and fabricated into 100-lb. multiwall flour bags. The bags were standard four-ply bags constructed of three plies of 40-lb. natural kraft and one ply of 50-lb. natural kraft. The outer ply of the treated bags had 50 mg. piperonyl butoxide and 5 mg. pyrethrin per sq. ft. with the Pyrenone on the outer surface. Half of the treated bags had no treatment on the tuck-in sleeves and the rest were treated.

In December, 1948, test bags comparing the various combinations of treatments with untreated bags were filled with sterilized flour at each of two well-known flour mills and shipped to two independent laboratories. The tests were made at 83°F. and 65% R.H. which was considered optimum for the propagation and activity of the insects.

TEST RESULTS AND CONCLUSIONS

In both laboratory tests, the filled bags were placed in steel chests and a large number of cadelles, confused flour beetles, and sawtooth beetles were placed on top of the bags along with a small amount of flour for food. At the end of the 8-week period, the chests were opened and the contents of the bags sifted to determine the number and types of insects that entered the bags. The conclusions from the results obtained by the tests at both these laboratories were:

1. The multiwall bags having the outer ply and sleeve coated with Pyrenone applied under commercial machine conditions were completely resistant to all the insects employed in these tests. Furthermore, practically all the insects placed into the chests containing this type bag were killed by contact with the paper bags.

2. The type bags having a Pyrenone impregnated outer ply and sleeve were not completely resistant to insect penetration showing that the surface coating method with the same amount of insecticide was more effective.

3. Creped kraft sleeves coated with Pyrenone were not penetrated by any of the insects; heat sealed resin coated sleeves were resistant to all the insects except the cadelle, which bored through the resin coated sleeve.

TOXICITY OF PYRENONE

After the Pyrenone insecticide coating had been proved to be effective and commercially feasible, it was necessary to prove the Pyrenone to be of low toxicity in order to obtain approval for its use in bags to package products for human consumption. An article by Lehman (*1*) presented data which indicate that the acute oral toxicity of Pyrenone is negligible. Also, that Pyrenone is not dangerous when applied to the skin. In closing, Lehman stated, "Combinations of pyrethrins and rotenone with the two insecticide activators, piperonyl butoxide and *n*-propyl isome, appear to be the safest for use from all standpoints. However, even here the possible limitations of these combinations await the outcome of the more prolonged laboratory observations, especially lifetime feeding studies of the activators." In addition to these statements on the toxicity of Pyrenone, unused bags from the insect resistance tests were submitted to the U. S. Pure Food and Drug Commission for their analysis. As a result, permission was granted for the use of the desired coverage of Pyrenone as the outer surface on a multiwall paper bag for flour.

FIELD TESTS WITH TWO CARLOADS OF PYRENONE-TREATED BAGS

The next step was to make arrangements with two large flour milling companies for shipments of Pyrenone-treated bags in badly infested boxcars. The first test was made in conjunction with Pillsbury Mills, Inc. and Continental Baking Co. On Aug. 2, 1949, a railroad car containing 900 bags of sterile flour packed in pyrenone-treated multiwall bags was shipped from Enid, Okla., to Continental Baking Co's plant at Memphis, Tenn. The test bags were standard 100-lb. flour bag construction having the Pyrenone on the outer ply, sleeve, and bound over tape used on the sewn ends. The bags were loaded into a new freight car which had been thoroughly cleaned, fumigated, and lined with soft finish carliner paper. Between 3000 and 4000 live red rust beetles were scattered on top of 10 rows of bags at the brake end of the car.

Sixty-five hours later at Memphis, the car was carefully unloaded under the supervision of George B. Wagner of Pillsbury Mills, Inc. Of the 3000 beetles originally present, 2361 were dead, 287 paralyzed or in a coma, and the remainder unaccounted for, although they probably escaped into cracks in the freight car. None of the beetles was able to get into the treated bags, prov-

ing that the Pyrenone treatment offered complete protection against insect penetration under extremely severe conditions. It is significant to note that the toxicity of the Pyrenone to the beetles was so great that only three beetles were found in the opposite end of the car from the end that they were placed. The lack of migration is especially interesting when the beetle's ability to fly is considered.

The second test at the Commander-Larrabee Flour Mills Co., St. Joseph, Mo., was similar to the Pillsbury-Continental test except 2000 confused flour beetles were placed in a carload of 990 Pyrenone-treated bags filled with sterilized flour and shipped to the Continental Baking Co. plant at Paterson, N. J. On Aug. 29, 1949, or 2 weeks after the insects were placed in the car, the freight car and contents of the bags were inspected. No beetles were found in any of the bags proving again that Pyrenone-treated bags were completely resistant to insect penetration. A total of 2697 beetles and larvae were found in the freight car, of which all were dead except 47 that were in a coma or paralyzed.

COATING METHODS

Some of the earlier coatings were made by using a paper machine size press to apply the insecticide coating of water emulsifiable Pyrenone, clay, and starch adhesive. These coatings were successful from the insect repellent standpoint, but the emulsifying agents destroyed the sizing of the natural kraft paper. Since sizing of the outer ply of multiwall bags is an important factor in bag performance, extensive work was undertaken with the supplier of Pyrenone to develop a new coating formula that would not affect the sizing. Since the most concentrated form of Pyrenone was a dark brown liquid similar to oil, it was found that it could be readily impregnated onto a clay powder for subsequent application as a size press coating using a starch adhesive. It was necessary to keep the pH of the coating formula slightly acid, as alkaline conditions cause decomposition of the Pyrenone. Also, the base paper had to have some wet-strength resin to achieve satisfactory sizing. The Pyrenone-impregnated powder contains 25% Pyrenone concentrate and the balance clay. Since the insecticide concentrate has $^2/_3$ piperonyl butoxide, the amount of Pyrenone-impregnated powder to give 50 mg. piperonyl butoxide per sq. ft. would be 2.0 lb. per ream 24 × 36—500.

It is possible to use a size press to apply Pyrenone on almost any type of paper ranging from flat kraft to creped kraft although wet-strength resin is needed to give adequate sizing. If a size press is not available, Pyrenone can be applied by an off-machine coater using some modification in the coating formula, which has a deteriorating effect upon rubber covered applicator rolls.

STABILITY OF PYRENONE COATINGS

It has been found that Pyrenone coatings will lose their effectiveness over a period of time. Tests on rolls of treated paper that have been stored over a year have shown little loss of insecticide. However, the combination of exposure to air and sunlight can cause fairly rapid loss of Pyrenone. Despite this adverse effect of air and light on Pyrenone, it has been found that Pyrenone-treated bags were effective for at least 6 months' storage. A test by an independent laboratory under very severe conditions showed that Pyrenone treated flour bags were effective after 9 months of storage, but have lost most of their insect repellency after a year's time.

ANALYTICAL METHODS

During 1949, St. Regis cooperated with Federal agencies covering description, performance standards, and testing methods for insect resistant multiwall bags. This work led to Amendment 1 of JAN-P-137; the Army-Navy Specification for overseas shipment in bags and sacks. In order to determine compliance with this specification, much work has been done with various methods of chemical analysis to check the amount of insecticide present on treated paper. The best methods to date have shown about ± 20% accuracy in round robin tests with a number of laboratories. Apparently it is difficult to analyze for small amounts of insecticide as extraction of the treated paper takes out small amounts of materials that interfere with the accuracy of the colorimetric test.

TESTS WITH OTHER INSECTICIDES

For the most part, work with insect repellent coatings by the St. Regis Paper Co. has been mainly with Pyrenone, since it was proved to be very effective and virtually nontoxic to humans. However, in the last 4 or 5 years, a large number of other insecticides that were known to be effective against insects in general have been evaluated. The tests included synthetic pyrethrin substitutes, other activators for pyrethrins, DDT, toxaphene, methoxychlor, chlordane, and lindane. The conclusions from laboratory tests were that Pyrenone was still the most effective but that lindane and methoxychlor showed promise as insect repellent coatings. Based on these results, coatings of Pyrenone, piperonyl butoxide, plus allethrin, methoxychlor, and lindane were applied on the size press of a paper machine.

The treated papers were fabricated into 50-lb. multiwall flour bags with the coating on the outer surface and the same treatment on the sleeve and sewn ends. The bags were filled with sterilized flour and subjected to extremely severe insect infestation conditions for over a year at a testing laboratory. The author is not at liberty to give specific test data, but it can be said that Pyrenone offered the most effective resistance up to about 9 months' storage. The lindane and methoxychlor showed toxicity toward the insects over a longer period of time. However, insects were able to go through the needle holes of the treated sewn ends showing that these insecticides are not completely as effective as Pyrenone for sewn end multiwalls. The greater effectiveness of Pyrenone together with the fact that both lindane and methoxychlor are much more toxic to humans indicates that Pyrenone remains the best-known insecticide for use as insect-repellent coatings for packaging products intended for human or animal consumption.

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Premix Food Packages and Some Chemical Treatments to Reduce Penetration by Insects

H. E. GRAY

The manufacture of premix foods is now an important industry. To satisfy the public the product must reach the consumer in an insect-free condition. In addition to maintaining the manufacturing plant free from insects, the product must be packaged in a container that will be extremely resistant to insect penetration during shelf life. Mechanical exclusion of insects by the use of a well-designed, tightly glued, preferably overwrapped package is the best protection against infestation. Experimental work has shown that the application of Pyrenone (piperonyl butoxide-pyrethrins mixture) to the packages reduces the possibility of insect penetration at a trifling cost. The use of chemicals is not a substitute for a well-designed, smooth, properly sealed, and durable container.

THE infestation of food packages by insects is a recurring problem for the processor of cereal products. It occurs most commonly during the shelf-life period in the premises of the retailer. The manufacturer must not only turn out a material that is free from insects at the time of packaging, but he must also use containers that are highly resistant to insect attack if his product is to be accepted by the public.

The packaging of cereal products has undergone much change during the twentieth century. The average size of the package has been greatly reduced. After the introduction of paper containers in the 20's, their use has gradually increased until today they are the most popular type. Changes in our living and food-buying habits have been responsible for many of the trends in packaging. The present popularity of the premix food packages is a good example of the streamlining of food preparation in the modern home.

During the past half century the public has become increasingly conscious of insect pests that contaminate food. This has prompted food manufacturers to put their products in better containers. The activities of the food and drug officials and the widespread program of food plant sanitation in North America have also increased the interest in insectproof packaging.

PREMIX FOOD PACKAGES

The preparation of mixtures of baking ingredients in ready-to-use form is now an important industry. The manufacturer of premix foods has two important problems to solve: (1) the prevention of rancidity and (2) the prevention of insect penetration. Both of these problems are closely related to shelf life. Carlin (*1*) found that suitable liners that prevented the contact of fats and oils with the cardboard shell greatly increased the shelf life of fats and fat-containing foods. For the premix food package a liner is essential.

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Types of Containers

During the past 5 years many premix food containers have been examined at the Ottawa laboratory. In general they fall into three main types: (1) lithographed cartons, (2) lithographed cartons with a transparent overwrap, and (3) a plain shell with a lithographed overwrap.

In the first group the protection of the product from insect contamination depends very largely on the tightness of the closure of the carton. This is the cheapest type of package. Some of those examined were extremely poorly designed as well as poorly sealed.

The second type is similar to the first save that it has been overwrapped with a transparent film, usually cellophane, which is normally heat-sealed. Commercial samples are frequently not well sealed. Rough handling in shipping, particularly in cold weather, often produces breaks in the film.

The plain shell with the lithographed overwrap is usually the best package of the three. Even if the shell is not well sealed, a lithographed overwrap seals the normal points of entry. A really good seal by the use of the overwrap is possible largely because of the even pressure provided by the inner shell.

Package Shortcomings Make Insect Penetration Easier

The shell blanks are stamped out of standard carton board. Lack of care in the adjustment of the stamping machine, or if the board is even slightly out of line, will produce substandard cartons with small openings that are readily found by stored product pests.

The gluing of the side joint to form the carton is another operation that must be carried out carefully. If the joint is out of line, the flaps that form the bottom and top will not fit together properly and a corner opening will be present.

Gluing the Flaps

The glue contacts on the bottom of a lithographed carton are usually superior to those made on the top after the package is filled. In many cases the bottom seal is made on a form that affords a steady pressure from within. Much of the difficulty in securing a good top seal is the lack of pressure from within the package. From an examination of a large number of premix packages the writer feels that the lack of glue is responsible for many of the poor seals. Proper sealing of packages is most important in preventing insect penetration. Packaging machinery must receive adequate attention to maintain it in proper working condition. Too often adjustments are made only when the equipment is functioning very poorly.

Hand-Sealing versus Machine-Sealing

The question may be asked: "Is it possible by any method to seal premix food packages tightly enough to prevent insect penetration?"

When packages were hand-sealed in the laboratory the degree of penetration was lower than that in machine-sealed packages. Machine sealing varies in efficiency throughout the run. A constant check must be maintained at all times to ensure that the packaging machine operates at peak efficiency.

A Package Infestation Survey

An analysis was made of a large file of data accumulated by one of the larger manufacturers of premix foods in the United States. This company regularly picks up samples of their products from retail stock at random throughout the country. These packages are examined for insect infestation and for packaging faults. The data afforded a good cross section of the pests most likely to be encountered.

The information showed that species of insects vary considerably in their abilities to penetrate packages. The species found in hot-roll-mix packages are arranged in order of frequency of occurrence in Table I. Five common stored-product pests were responsible for over 95% of the infestation. Over half of the infestation was caused by pests that are rarely, if ever, found in flour mills. The two flour beetles are common mill pests but are also found widely in stored grain, in railroad cars, in warehouses, and in retail stores. Almost all of the infestation of premix foods occurs during the shelf life in retail stores. The cadelle, a species that has been used widely in package-testing work, was responsible for less than 1 per cent of the infestation.

Package Improvement

We should all like to have a cheap container that would be proof against all insect pests. At present that is an ideal that can be attained only by the use of metal cans or glass containers. Neither of these containers is cheap or available in sufficient quantity; hence, it will be necessary to improve our present containers to meet our needs.

It was felt that improvement in the present type of packages could best be brought about by treating them with chemicals that would reduce insect penetration by either killing or repelling the insect pests.

CHEMICAL TREATMENT OF FOOD CONTAINERS

A variety of chemicals (*2–9*) have been used by different investigators for the treatment of food containers. The ideal material would be nontoxic to humans and at the same time highly toxic or repellent to all stored-product pests. Furthermore, the treatment must not affect the appearance of the food container. A survey of available materials showed that piperonyl butoxide-pyrethrins mixture appeared to be the most promising for insectproofing of food containers.

Table I. Occurrence of Insect Species in Hot-Roll-Mix Packages of a Leading Manufacturer in Retail Stocks in the United States, 1949

Species	*No. of times found*	*Per cent*
Saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.)	114	35.9
Confused flour beetle, *Tribolium confusum* Duv.	91	28.6
Indian-meal moth, *Plodia interpunctella* (Hbn.)	45	14.2
Larder beetle, *Dermestes lardarius* L.	27	8.6
Red flour beetle, *Tribolium castaneum* (Hbst.)	25	7.9
Cadelle, *Tenebroides mauritanicus* (L.)	3	0.9
Miscellaneous (dermestids, ptinids)	6	1.8
Accidentals	7	2.1
Total	318	100.0

Experimental Procedure

Scope of Experiments. One of the practical objectives of the tests was to determine whether chemical treatment of the lithographed type of package would render it sufficiently free from insect penetration to avoid the necessity of using an overwrap.

Tests were carried out to determine the effect of treatment with different concentrations of different Pyrenone formulations in preventing penetration of premix food packages by common stored product insects. The effect of applying different amounts of Pyrenone was also studied. Some tests were run with packages in which 0.85% Pyrenone had been incorporated into the glue; tests were run on the packages as received and after treatment with Pyrenone solution. A series of tests were also carried out to determine the effect of insect food supply on the protection afforded by Pyrenone against penetration by insects.

Some studies were carried out in cooperation with a leading Canadian firm of coaters of fiber board and similar products to determine whether Pyrenone could be successfully incorporated into varnishes and lacquers used in finishing.

Because of the cost of natural pyrethrum, a few tests were also run with solutions in which pyrethrin substitutes were used in place of pyrethrins. Everban F 1001 was used for the tests.

Materials. Through the courtesy of the United States Industrial Chemical Co. a series of Pyrenone (piperonyl butoxide-pyrethrins mixture) formulations were made available. These are referred to as 50–5, 30–5, and 20–5. In each case the first figure is the amount of piperonyl butoxide and the second the amount of pyrethrins expressed as grams per 100 ml. These concentrates were diluted with Shell odorless base oil. United States Industrial Chemical Co. also furnished Pyrenone in a suitable form for incorporation into varnishes and lacquers.

The National Starch Products Inc. furnished a supply of Beetle-Pel WA adhesive, which contained 0.85% of Pyrenone. This was used to test the effect of the incorporation of Pyrenone into the adhesive used in sealing the packages.

A supply of Everban F 1001 was furnished by McLaughlin Gormley King, Minneapolis, Minn. This product contains allethrin and an activator or extender. The concentrate was diluted with Shell base oil at the rate of 1–10, 1–20, and 1–50 and applied by the roller technique.

Much of the experimental work was carried out with lithographed cartons. A large number of filled packages of cake mix were supplied by a leading Canadian milling company.

Applying Pyrenone Solutions. In most of the tests the solutions were applied by means of a special applicator. This consisted of a set of 12 rubber rollers, 1 in.

Table II. Ratings (100% = 60) of Various Concentrations of Pyrenone Solutions in Protecting Premix Food Packages Against Insect Penetration when Roller-Treated with 2 Ml. Each

Dilution	Formulation 50–5	30–5	20–5
1–2	60	60	60
1–5	55	55	50
1–10	..	60	10
1–10	38	..	..
1–20	44	38	38
1–50	44	36	30
1–100	..	38	52
1–200	..	52	52
Check	14	14	14

in diameter, mounted in a metal frame. The frame was placed in a shallow metal pan filled with sufficient of the Pyrenone-oil mixture to cover the lower surface of the rollers. The packages were treated by a single pass over the rollers of the surfaces to be treated. Before treating the first package of each lot, a blank package was passed over the rollers to coat them with the solution.

After the treatment of a set of packages with a particular dilution, the solution was returned to a stock bottle. The rollers, stand, and tray were then washed with soap and water, rinsed, and dried.

In some tests the solutions were applied to small areas on the packages with a sash brush.

Drying. After treatment the packages were placed on coarse screen trays and allowed to dry for 24 hr. before testing.

Exposure. After drying, the cartons were placed in test cabinets approximately 6 ft. long and with a cross section of about 30 in. square. The cartons in any test chamber were arranged in series to facilitate removal at intervals of 2, 4, 6, and 8 months. As a result, some of the packages in any set were placed at four different places in the cabinet.

As the highly concentrated solutions killed all of the test insects in the cabinet, the packages treated with dilutions of 1–2 and 1–5 were placed in individual metal containers for all but the first few weeks of the test.

Test Insects. The test material was kept at room temperature in chambers containing large populations of five species of stored product pests: the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.); the Indian-meal moth *Plodia interpunctella* (Hbn.); the confused flour beetle, *Tribolium confusum* Duv.; the black carpet beetle, *Attagenus piceus* (Oliv.); and the Mediterranean flour moth, *Ephestia kühniella* Zell. About 12 months after the start of the work the last two species were no longer used because of the few times in which they gained entrance to packages.

Table III. Ratings (100% = 60) of Various Amounts of Pyrenone Solutions (Formulation 50–5) in Protecting Premix Food Packages Against Insect Penetration

How treated	Amount applied, ml.	Dilution 1–5	1–10
With roller			
Top and bottom only	1.25	50	52
Top, bottom, and two sides	2.0	53	38
Top, bottom, two sides, front, and back	3.0	60	60
Check	0.0	12	12
Hand-brushed			
Junction of top and sides	0.8	..	52

Table IV. The Effect of Food on the Ratings (100% = 60) of Pyrenone Solutions (Formulation 50–5) in Protecting Premix Food Packages Against Insect Penetration

How treated	With food	Without food
Roller-treated		
Top, bottom, and 2 sides, 2 ml. each		
Dilution		
1–10	53	45
1–20	45	44
1–50	18	41
Hand-brushed, 1–10 dilution		
Junction top and sides		
Band		
1 in. wide	12	30
2 in. wide	18	60
4 inch wide	6	58
Check	16	28
Average of all treatments	25	46
Commercial production procedure	20	34

The supply of insects was renewed each month. In many of the tests, food was supplied in dishes in the cabinet. When food was supplied, a thin layer was also scattered over the tops of the cartons.

Examining the Packages. The packages were opened by cutting completely around each box about half an inch below the top with a razor blade. A cut at this point did not damage the liner and permitted the removal of the liner and its contents intact.

Each shell was examined for insects as well as for pinholes and package defects. A binocular loupe was used for much of the examination. The surface of the liner was then checked for holes and for insects. The liner was then opened and the contents were examined.

The glue joints, between the short side flaps and the long inner flap and between the long inner and outer flaps, were broken on both the top and bottom of the package. The percentage of glue contact in each case was estimated by a transparent scale and the results were recorded.

Numerical Rating. The packages were rated on the basis of package-months free from penetration. Each package showing no penetration at the end of 2 months was credited with 2 points, at the end of 4 months with 4 points, at the end of 6 months with 6 points, and at the end of 8 months with 8 points. In most cases the tests were carried out for 8 months and 3 samples were withdrawn on each examination. In this case a perfect score would be 60 points. In a few cases the tests were terminated at 6 months, when a total of 36 represented a perfect score.

Results and Discussion

The tables that follow indicate the more important trends. The word "trends" is used advisedly because the results are not as clear-cut or precise as one hopes

Table V. The Effect of Food on the Order of Importance of Test Insects in the Penetration of Premix Food Packages Treated with Pyrenone Solutions

	With food	Without food	Total
Number of packages	132	132	264
Number penetrated	61	34	95
Per cent penetrated	46	26	36
Present by per cent			
Saw-toothed grain beetle	93	53	80
Flour beetles	30	62	43
Indian-meal moth	6	9	6

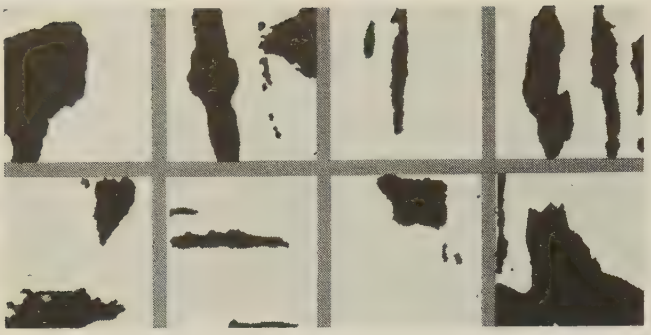

Fig. 1. Photographs of typical glue contacts (in black) between short side flaps and long inner flap on premix food packages. Note the small area of glue contact

to secure in experimental work. The data selected are typical, all representing a considerable number of tests. In each case the results used were obtained in the same test cabinet, as it is not always possible to compare the results secured from different test runs.

An uncontrollable variable is the inherent difference in the tightness and efficiency of the sealing of the individual packages. The packages are stamped on machines and formed and sealed on still other machines, all of which require adjustment and maintenance. Some of the packages are better than others but there is no way of determining which are superior, average, or poor until the test is over. In one series, at the end of two months' testing every package in the experimental lot from one stamping machine had a small opening in the upper right-hand corner. All of these packages had been penetrated. For this reason it is important to check the shells carefully for holes, defects, and percentage of glue contact.

Effect of Concentration. The results secured on the effect of concentration of Pyrenone in protecting premix packages from insect penetration are shown in Table II. This table is divided into two parts. The portion above the horizontal line gives the results with high concentrations, and the lower portion those with more dilute solutions. The 1–10 dilutions are not strictly comparable because of the method of handling (see above, under "Exposure").

When packages are treated with the higher concentrations of Pyrenone the test insects are killed by contact with the treated surfaces. This action has also been noted in the testing of treated paper and cotton flour sacks both in the laboratory and in warehouses.

All of the penetrated packages treated with the 1–10 dilution of formulation 20–5 showed evidence of poor sealing and the presence of entrance channels.

At lower concentrations Pyrenone appears to exert a repelling rather than a toxic action. There is apparently no clear relationship between concentration and the amount of protection afforded. All of the treatments afforded greater protection than the untreated check.

Effect of Amount Applied. The manufacturer is interested in knowing how much Pyrenone he should use to protect his packages from insect penetration. The data in Table III give some indication of the necessary level of treatment. In general, at least 2 ml. of Pyrenone solution (formulation 50–5 diluted 1–10 with a suitable oil) should be applied to each package, particularly at the points of closure.

Table VI. Ratings (100% = 60) of Various Dilutions of Everban 1001 in Protecting Premix Food Packages Against Insect Penetration When Roller-Treated with 2 Ml. Each

Dilution	
1–10	54
1–20	52
1–50	60
Check	14

The packages that were treated on all surfaces were not penetrated. Those receiving only partial coverage were protected to a material extent but not strictly in proportion to the amount applied. They were all much better than the controls.

Method of Application. In the experimental studies most of the Pyrenone was applied by the roller method. In some cases a brush was used to concentrate the Pyrenone at the points of closure.

The method of application merits further investigation. To satisfy the manufacturer it must be mechanized, fast, effective, and economical. Furthermore, the equipment must not take up very much space because it must fit into the packaging line between the sealing of the packages and their packing in cartons for shipment.

Glue Containing Pyrenone. Premix food packages that were sealed with glue containing Pyrenone were penetrated about half as frequently as those sealed with ordinary glue. The resistance of the packages sealed with the glue containing Pyrenone to insect penetration was further increased when a 1–10 solution of Pyrenone (formulation 50–5) was applied to the two sides, top, and bottom of the package.

Effect of Food on Chemical Protection

In general, when suitable food was present near premix food packages, there was more penetration of the packages than in its absence (Table IV). On the average, almost twice as many penetrations occurred when food was present.

Order of Importance of Test Insects. In attempting to evaluate penetration tests they must be studied in the light of the species used. Different species vary in their biology, and conditions that are favorable for one may not be so for others.

In these tests (Table V) the saw-toothed grain beetle penetrated 93% of the packages when food was present, but only 53% of those without food. The flour beetle

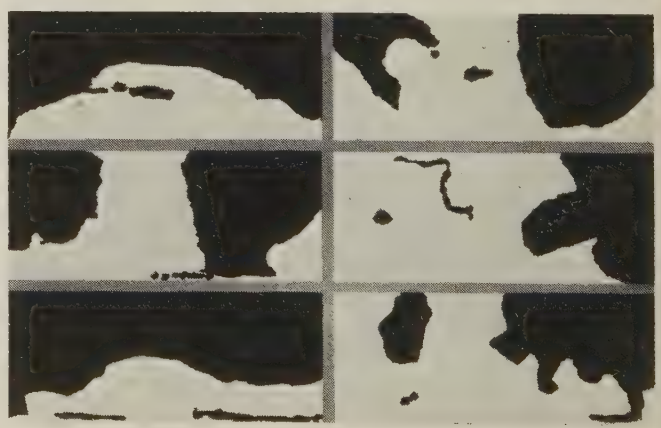

Fig. 2. Photographs of typical glue contacts (in black) between inner and outer flaps on premix food packages. Note the unglued areas through which insects can gain access to the packages

behaved in just the opposite manner, penetrating only 30% of the packages when food was available but 62% of those without food. The Indian-meal moth penetrated much less frequently than either of the others, but did so more commonly when food was lacking.

Incorporation of Pyrenone into Varnishes and Lacquers. A number of problems were encountered in mixing the Pyrenone with the coatings. All of the treated cartons were difficult to seal and the seals were readily broken. None of the formulations that performed satisfactorily as coatings were appreciably better than the check in preventing insect penetration.

Pyrethrin Substitutes. The packages treated with Everban F 1001 were highly resistant to insect penetration at the dilutions used (Table VI).

The packages treated with Everban F 1001 had a noticeable odor on them. It persisted in the test cabinet for over 2 weeks. It is commercial practice to pack the individual packages in cartons shortly after treatment. This would prevent aeration and it is probable that the odor would persist for at least several days after unpacking.

CONCLUSION

Insects penetrate food products most commonly when the product is on the retailer's shelves. Frequently the insects found in the product breed in the premises of the retailer. Infested transportation facilities may aggravate the problem. These sources of infestation are admittedly beyond the control of the manufacturer. However, to protect his brand name he must consider them as part of his packaging problem and provide protection against such invasion.

Mechanical exclusion is still the most practical method of dealing with such stored product insects. There has been considerable improvement in the closure of premix food packages. Regardless of its inherent or added repellency, a food container can successfully resist insect penetration only when possessing a smooth surface and when tightly sealed. If the package is poorly sealed the insects gain entrance readily. Folds, creases, seams, and rough spots assist the insect by providing points at which penetration is easily effected. Pour spouts and other "easy opening" features make it easier for the insects to penetrate the package.

The treatment of containers with chemicals that kill or repel the insects is a decided advance. One of the most promising chemicals is piperonyl butoxide-pyrethrins mixture, which possesses extremely low toxicity to higher animals. Treatment of premix food packages with different formulations of this mixture has greatly reduced the amount of penetration occurring in periods in excess of normal shelf life.

Chemical treatments can add to the resistance of package materials. They cannot act, however, as substitutes for a well-designed, smooth, properly sealed, and durable container.

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The Development of an Insect Resistant Folding Carton

[RICHARD I. RICE

A limited number of infestation tests in insectaria and in storerooms show that a Pyrenone-treated clay coated folding carton reduces infestation of stored products. Data on the migration of the insecticide from the coating to the contents of the carbon have been obtained for presentation to the Food and Drug Administration.

A series of coating experiments and entomological tests have been made to develop an insect resistant folding carton. The request for such a carton was made by an American milling concern which was experiencing infestation in premixes. The milling concern was using a printed folding carton, but was planning to convert to a chipboard shell with printed overwrap unless an economical insect resistant folding carton could be developed.

The recommended treatment for an insect resistant package was a coating of synergised pyrethrins and, based upon experiments involving houseflies and treated panels, the recommended dosage level on the surface of the package was 5 mg. of pyrethrins and 50 mg. of synergist per sq. ft. This dosage level had been first used by the St. Regis Paper Co. in treating the outer ply of multiwall bags and this treatment is prescribed in the JAN Specification P-137, Amendment 1 for multiwall bags for overseas shipment. The JAN specification states that a mixture of pyrethrins, a piperonyl butoxide and suitable carrier and bonding agents shall be coated on the outside ply to give a minimum recoverable concentration of 5 mg. of pyrethrins and 50 mg. of piperonyl butoxide per sq. ft. The specification further states that the coating shall have a pH of 5.0 to 7.0.

The coating described in the JAN specification is usually applied by means of a size press on kraft paper. The boxboard mill where the insect resistant boxboard was to be made was equipped with two air knife coaters operating in tandem in an off-machine coating operation.

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TEST PROGRAM

Contact Tests

Evaluating the insect resistant boxboard was to be by means of a contact test wherein flour beetles were imprisoned on the treated boxboard and observed for paralysis or kill over a period of several days. Thirty adult beetles, *Tribolium confusum*, were confined on top the treated boxboard under an inverted petri dish. Five samples of the treated boxboard were tested from each experiment with one control of untreated clay coated boxboard. The number of beetles used in each test was 180. The test was conducted in an insectarium with controlled temperature and humidity. The insects were examined and counted every 24 hr.

Infestation of folding cartons is usually through the closures of the carton. The reasoning behind the use of a contact test to evaluate the treated boxboard was that in an insect resistant carton infestation would be prevented by killing or paralyzing the adult insects upon contact before they could effect an entry through the closure or, less frequently, through the boxboard itself.

A substantial amount of infestation in food cartons is caused by nonboring insects and much infestation is by larvae hatched from eggs deposited in the crevices of the carton closures. Preventing infestation by larva would require that the adult female be killed or paralyzed before she could deposit her eggs under the glue flaps of the cartons. The factor of repellency was omitted in the tests because it was not realized at that time that repellency could be so effective in reducing infestation of food cartons.

The coating of the JAN specification had been proved in practice, but it was considered advisable to study various coating formulations and dosage levels. The entomological tests were performed by the milling concern, The Institute of Paper Chemistry, the manufacturer of Pyrenone, or our own laboratory.

When making contact tests with *Tribolium* the numerical results which are reported will vary with the criterion used for insect paralysis. In a contact test with *Tribolium* the first noticeable effect on the insect is the loss of control of one or more legs. The second stage is reached when the insect is unable to remain on its feet and continually falls over on its back. The third stage is reached when the insect is on its back paralyzed and only infrequently waves an antenna or a leg.

The milling concern which performed most of the contact tests observed three stages in the paralysis of *Tribolium*. The first stage, disturbed equilibrium, is similar to the first stage described above. The second stage is partial paralysis wherein the insect will move only after being prodded. The third stage is a coma, similar to the third stage as described above. The milling concern reported insects in any of the three stages as "paralysis," since insects in the first stage at 24 hr. would usually pass on to the second and third stage when kept confined on the treated board. In interpreting contact tests The Institute of Paper Chemistry considers an insect paralyzed only when it is on its back and remains immobile except for an occasional movement of a leg or antenna. In contact tests conducted in our laboratory results are reported by recording the number of insects visibly affected, completely paralyzed or dead.

The conclusions which can be drawn from the test results are that:

1. An insecticidal coating can be applied on boxboard which will paralyze or kill flour beetles held in contact with the coating.
2. For greatest contact effect the insecticide should be held on the surface.
3. The contact effect decreases with time.

The purpose of the contact tests was to determine what insecticidal treatment on boxboard was required to prevent infestation of folding cartons. What was lacking was a correlation between the tests and results in the field. It was safe to assume that a folding carton of treated boxboard which paralyzed insects on contact would not be likely to become infested, but such a treatment level was expensive and it was necessary to determine what lesser dosage would prevent infestation.

Among the important questions unanswered by the contact tests were the following:

1. A dosage of 30 to 40 mg. of pyrethrins and synergist on the surface of boxboard is capable of paralyzing *Tribolium*, but what initial dosage is required to paralyze *Tribolium* after the boxboard has aged 6 months?
2. What is the correlation between the contact tests and control of infestation in the field?
3. What is the cheapest acceptable treatment which will prevent infestation in folding cartons?

PENETRATION TESTS

Studies of infestation in products packed in folding cartons show that most cartons are entered through the closures of the carton and not through the boxboard. Abrasive coatings on the surface of the boxboard have been shown to reduce penetration and the tests tend to show that untreated clay coated boxboard (5 to 6 lb. of clay coating per 1000 sq. ft.) has considerable resistance to penetration by cadelle larvae.

INFESTATION TESTS

Several food processors were supplied with unprinted cartons made from Pyrenone-treated boxboard. These cartons were filled and sealed on the packaging line and then placed in insectaria with untreated cartons as a control.

It has been shown that the infestation resistance of a carton varies with the tightness of the seal. Cartons sealed by hand are generally more resistant to infestation than cartons sealed on the packaging line and in making infestation studies the tightness of the closure should be carefully controlled.

One test was made on a quantity of Pyrenone-treated cartons filled with cake mix. Twelve each of treated and untreated cartons were placed in a insectarium with a large quantity of five species of stored product pests. Every 2 months three cartons were removed from the insectarium and examined for infestation. For numerical rating, each carton withdrawn showing no penetration at the end of 2 months was scored two points, at the end of 4 months four points, at the end of 6 months six points, and at the end of 8 months eight points. A perfect score would have been 60 points. The treated boxboard was 6 months old at the time of

the test and had an initial dosage of 13 mg. of piperonyl butoxide.

One infestation test was made in which the treated folding carton was compared with a chipboard shell and printed tightwrap. The chipboard shell with printed tightwrap is less subject to infestation than the printed folding carton due to the better seal obtainable with the tightwrapped carton. Despite the poorer appearance of the tightwrapped carton and its poor opening properties, the manufacturers of printed folding cartons have seen many large food processors swing to the tightwrap carton in the last 10 years. In the infestation test comparing the treated folding carton and the tightwrap carton the results were superior with the treated folding carton and the food processor has definite plans to convert to the treated folding carton in order to reduce infestation from the level now experienced with the tight-wrap carton.

The only field test made with the Pyrenone-treated cartons was conducted by a concern in the south. Unprinted Pyrenone-treated cartons were filled with the product and sealed on the packaging line. The treated cartons were packed with standard cartons in a corrugated case and two cases were stored in two stores in Alabama and Mississippi. At the end of 5 months not one treated carton was infested while every one of the untreated cartons in the two cases was infested.

The infestation tests in insectaria are severe and results show that dosages of less than 55 mg. of pyrethrins plus butoxide tend to give spotty results. Nevertheless, the conclusion made by us from the entomological tests was that we could assure a food processor that a Pyrenone-treated carton would reduce infestation to a satisfactory level.

Only two commercial runs of insect resistant cartons have been made to date. The first run was for several hundred thousand cartons for patent medicine. The cartons controlled infestation well, except that at the end of 10 months reports of infestation were received. A second run of cartons has been made at a higher dosage level in an effort to control infestation for a longer period. No results have been received on the second run of cartons.

FOOD AND DRUG ADMINISTRATION

The pure food laws state that a food is adulterated if its container is composed in whole or in part of any deleterious substance which *may* render the contents injurious to health. Before the Food and Drug Administration will withdraw its objection to use of a certain ingredient in the packaging material it is necessary to present facts proving the low order of toxicity of the ingredient and facts proving that there is no migration of the ingredient to the food contained in the package. The F.D.A. has been presented facts proving the low order of toxicity of pyrethrins and piperonyl butoxide. It has been conceded that a residue of 10 p.p.m. on fruits and vegetables would be safe. This concession is based upon the fact that normal processing would reduce a residue of 10 p.p.m. on raw fruits and vegetables to a much lower level in the food as eaten. Similar reasoning underlies the permission granted to add 13 p.p.m. of Pyrenone to stored grains intended for human consumption.

MIGRATION TESTS

Pyrenone migration tests involve quantitative analyses for piperonyl butoxide in the food contained in the treated carton. The Food and Drug Administration suggests that the treated cartons be stored at slightly elevated temperatures and humidities and that the analyses be made for a storage period as long as the maximum shelf life of the carton of food.

Migration tests on a cake mix carton with laminated glassine innerbag, a patent medicine carton, and two sets of cereal cartons have been made.

The migration study on the cake mix carton was made by measuring the butoxide in the glassine liner, since an analysis for butoxide in the presence of the shortening in the cake mix was not possible. The absence of butoxide in the glassine liner was considered to be proof that piperonyl butoxide had not migrated to the cake mix.

With the patent medicine carton the migration of butoxide was generally found to be less than the limits of detection, that is, less than 1 p.p.m.

The analyses of the piperonyl butoxide content of the cereal were made on the total contents of the carton since the loose pack of the carton resulted in considerable mixing of the contents of the carton. The Food and Drug Administration is interested in the butoxide content of the food in contact with the inside liner of the package and the lack of this information may be a defect in the presentation which will be made to the F. D. A.

The Food and Drug Administration asks for a butoxide content in the food in the form it is consumed. In the case of the cereal there is a dilution factor of 7 : 1 and the butoxide content in the food as eaten would be less than 1 p.p.m. in most cases.

Some knowledge of the mechanism by which butoxide migrated from the coating on the outside of the carton to the cereal was needed and a migration study was made on a 65-in. skid of Pyrenone-treated boxboard stored at room temperature. The results of this study prove that the piperonyl butoxide content of the boxboard is fairly stable, but that there is a definite migration of the butoxide from the surface to the rest of the boxboard.

ECONOMICS

There is a real need for an insect resistant carton, but the cost of such a carton has been a deterrent to its widespread use. At \$6.00 per lb. for synergised pyrethrins the recommended dosage of 50 mg. of synergist and 5 mg. of pyrethrins per sq. ft. costs 0.7 mill per sq. ft. of boxboard. An 8-oz. cereal carton $2^1/_4$ by $5^1/_8$ by 8 has a surface area of 1.28 sq. ft. Assuming a 90% recovery of insecticide in the coating operation and an 8% loss in carton manufacture the cost of the insecticide coating on the cereal carton is 1.1 mills. To this must be added the cost of the insecticide in the carton inks and adhesive which makes the total upcharge for the treated carton approach \$2.00 per thousand cartons. For a concern using 20 million cartons a year this is an increase in carton costs of \$40,000. The actual cost of infestation to such a concern would be much less than \$40,000 and the margin of profit in the food industry is too small to justify such an expenditure. In some cases the upcharge might be warranted. Concern ABC

which markets a large line of premixes would consider an insect resistant carton for those premixes which are most subject to infestation, the reason being that a housewife who found insects in a carton of chocolate cake mix might be prejudiced against buying any of the ABC line of products, including those products which are seldom infested. A mother who finds an insect in a carton of baby cereal will react in a different manner than a housewife finding an insect in a box of raisins and the manufacturer of baby cereals might be prepared to pay the extra cost of the treated carton. For years there was a prejudice against dog foods in cartons due to the infestation in storerooms and warehouses which was traceable to corrugated cases of dog food in folding cartons.

Since the upcharge for a treated carton is based upon the cost of the insecticide the discovery of a cheap nontoxic insecticide would be of benefit to the packaging industry. For agricultural purposes an insecticide should be nonrepellent, for if the insecticide were repellent the insects would avoid any contact until the insecticide had been transformed to a less toxic compound. For use on packages the ideal chemical would be highly repellent. There are many chemicals whose repellency to stored products insects remains untested and it is probable that a relatively cheap repellent will be discovered.

Another approach to the problem of the expense of the treated carton involves the definition of the goal which is being sought.

Most of the goals for reduction of infestation in food cartons are set at 100%. Perhaps a reduction of 80% in infestation complaints should be considered as a satisfactory balance between the cost of the complaints and the cost of the treatment. In that case the logical approach to the problem of costs would be to conduct large scale tests in the field using cartons with only half the recommended dosage.

The results tend to prove that a treatment of 30 mg. of pyrethrins plus synergist on clay coated boxboard will in actual practice give a worth-while reduction in infestation for a period of 6 months or more, despite the fact that infestation tests in insectaria were shown to be no more than fair at the 30-mg. level of treatment. The infestation tests under the artificial conditions in an insectaria should not stand in the way of large scale field trials with several hundred thousand cartons. Only by such large scale tests can the required treatment level and thus the cost of the carton be determined.

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A Laboratory Method of Evaluating the Repellency of Treated Paper to Stored-Product Insects

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A technique is described for the evaluation of the repellency to stored-product insects of candidate compounds when applied to paper. The method consists of continuously exposing adult flour beetles for 5 days on an arena composed of equal areas of treated and untreated paper. Tests are run in quadruplicate with 10 insects in each replication; the insects being retained on the test papers by open-end glass cylinders. Comparisons of the repellent action of the experimental compounds are made on the basis of the number of insects counted twice daily on the untreated halves of the arena, and then taking the average of the 10 readings. A treated standard and an untreated check are included in each series for comparison. An example of the method used to present the results is shown, and data are cited to substantiate the technique.

During the past 5 years, this laboratory has been making laboratory, semipractical, and warehouse tests to evaluate the effectiveness of insecticide treatments applied to paper and cloth bags and corrugated cartons to prevent the infestation of various stored products. The early phases of this work were largely directed toward semipractical or warehouse tests, laboratory tests being rather limited and mainly exploratory in nature. The desirability of having laboratory tests which would be correlative with the semipractical tests was obvious. One reason is that it would be entirely impossible and impractical to attempt to evaluate hundreds of experimental compounds by semipractical tests.

Efforts were directed, therefore, during the time in which these first warehouse tests were in progress, to develop laboratory tests which would be indicative of the expected performance of a given treatment in the warehouse. The laboratory tests which appeared to be more promising were the following: (1) a test to determine the toxicity of various compounds to stored product insects, (2) a test to demonstrate the property of various compounds to repel stored-product insects, and (3) a test to show the resistance to insect penetration by certain insecticide-treated papers. This paper is a description of a test developed in the second category; namely, a repellency test.

The first semipractical test conducted at the Savannah laboratory included paper bags which had been treated with synergized pyrethrum. This is the only insecticide treatment which is accepted for use on food packages at the present time and which is available as a commercially coated paper. It was during this time that the laboratory tests began to show that treatments which produced no mortality to adult flour

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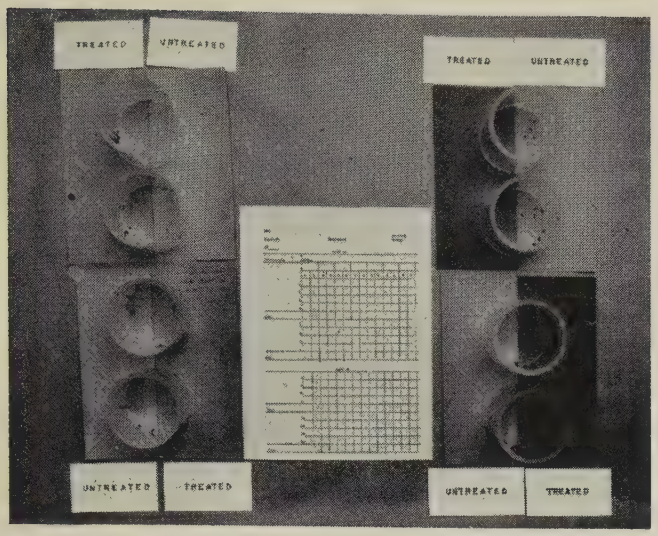

Fig. 1. View of the repellency test setup

Note that the treated halves of the two sections are reversed. Two glass cylinders are used on each section and ten insects are used in each cylinder.

beetles did show a tendency to repel them. When paper from the bags having the synergized pyrethrum treatment tested in the warehouse was tested in the laboratory, it showed no toxicity. But it did show repellency to adult flour beetles even after the treatment had aged for 1 year. Since this finding indicated that repellency is an important factor in the protection rendered by treated papers, considerable emphasis has been placed on the development of a repellency test.

It is not the purpose of this paper to describe the evolution of the test, as there probably would be little value in a description of all of the techniques which have been tested. The purpose of this paper is to describe the technique of the repellency test as it was finally perfected and to present certain data which led to its adoption.

The insects used in the repellency tests are adults of the confused flour beetle, *Tribolium confusum* Duval and of the red flour beetle, *T. castaneum* (Herbst). Both species are reared in a culture medium consisting of 50% of flour, 45% of corn meal, and 5% of brewer's yeast. Rearing is conducted in a room maintained at 80 ± 2°F. and 60 ± 5% R.H.

Ten new cultures are started each week and the rearing cycle runs for 8 weeks. At the end of the fourth week before any new emergence occurs, the original adults with which the cultures were started are removed. On Friday of the eighth week the newly emerged adults are removed from each of the 10 cultures and placed in a jar containing flour. If a card is placed in the jar, large numbers of insects congregate on the card. This behavior is utilized in the collection of the insects which are used in the tests on the following Monday. Since the parent adults were removed, the age of the test insects is from 3 to 28 days.

Acetone solutions of experimental candidate repellent compounds are prepared by weighing into a 50-ml. volumetric flask the calculated amount of each compound. Thus, when 4 ml. of the finished solution is applied to a 4 by 16-in. strip of kraft paper, the desired number of milligrams of the active ingredients are deposited on each square foot of paper. Application of the 4 ml. of solution to the paper is made by using a pipet. This volume of solution spreads very evenly over the 4 by 16-in. strip of paper. The treated papers are labeled and allowed to dry for 4 days before the tests are started.

The repellency test sheets consist of a strip of treated paper jointed edge to edge with cellulose tape to a strip of untreated paper. A perfectly matching seam is obtained by slightly overlapping the edges of the two strips of paper and making a single cut with a razor blade along a straight edge. The joined strips are then cut into two sections each being 8 in. long and approximately 7 in. wide. As shown in Fig. 1, the two sections are placed on a table so that the treated half of one is turned to the right and the other to the left. Two glass cylinders are placed on each of the two sections of paper. The cylinders are positioned so that the seam joining the treated and untreated papers forms the diameter of the test arena, thus providing equal areas of treated and untreated paper. The reason for cutting the treated papers into two sections and turning the treated halves of each section in opposite directions is to counteract any undetermined external influences on the distribution of the insects.

The glass cylinders which are used to confine the test insects on the repellency arenas are oil cup glasses which measure 3 in. in height, 3 in. in outside diameter, and are made of $^{3}/_{16}$-in. thick glass. Each end of these cylinders is machined smooth; and therefore, either end can be placed on the paper to produce an insect-tight union. These oil cup glasses have sufficient weight to press down folds which may be present in some of the treated papers.

Another readily-available cylinder which has been used in the repellency test can be prepared by cutting off the top 3 in. of a 16 or 18-oz. tea glass and smoothing the cut edge. This provides a cylinder having approximately the same dimensions as the oil cups. One disadvantage of the tea glass cylinders is that they have only one smooth end. In addition, their very thin gage and lightweight causes them to break more frequently than the oil cup cylinders. The possibility of any fumigant action by any of the experimental compounds is greatly minimized by the use of these open-top cylinders.

Each new series of repellency tests are begun on Monday morning and continued through 5 days. Ten adult flour beetles are placed in each glass cylinder. Counts are made twice daily to determine the number of insects on the treated and untreated paper in each arena. These counts are usually made in the early morning and in the late afternoon. Therefore, the data obtained amount to 10 readings of four cylinders or 400 individual insect positions for each treatment. The positions of the insects which are knocked down or dead are disregarded, and such insects are removed and replaced with active individuals. The average is determined for each reading of the four cylinders, and at the end of the fifth day the average for the daily readings is determined. This average is then converted to the per cent of the insects which were counted on the two surfaces.

Untreated checks are included in each series of repellency tests. The preparation of and the techniques used with the untreated check sheets are identical to

those described above with the exception that neither half of the paper is treated. On the untreated checks counts are made of the number of insects on each side of the seam. The reliability of the test is dependent on obtaining a 50-50 chance distribution on the two halves of the untreated check.

A standard is used in all tests for comparative purposes, consisting of paper treated with pyrethrins plus a synergist. The synergist selected for the standard was piperonyl butoxide, since it was one of the first ones available and more was known about it at the time these studies were started.

Table I is a typical presentation of the results of a repellency test. The percentage values shown for each of the treatments are the average number of test insects counted on the untreated half of the repellency arena for the entire 5-day period. The figures for the untreated portion of the arena are selected for presentation in order that high values may be associated with greater repellency. These figures can be converted to express per cent repellency or attractancy by doubling the difference between the percent of insects counted on the untreated half and the 50% expected distribution. The positive figures (+) would express repellency and the negative figures (−) attractancy. Before this method can be adopted, further statistical work should be done to determine the significant levels for both repellency and attractancy.

The results obtained with experimental compounds are compared with a standard in all tests. The standard consists of paper treated with synergized pyrethrum at the rate of 10 mg. of pyrethrins and 100 mg. of piperonyl butoxide per square foot. The readings for the untreated check arenas are tabulated as 50% plus or minus the deviations from the 50-50 distribution.

Each month following the initial tests, aging tests are conducted with the same papers to determine the persistency of the repellent action produced by the various treatments. These tests are conducted according to the procedure used in the initial tests and the results are tabulated and presented in the same manner.

Table I. Repellency to Adult Flour Beetles of Experimental Compounds Applied as Acetone Solutions to Kraft Paper

All tests were conducted in quadruplicate

Treatment	*Per cent of insects counted on untreated area*		
	Initial	*1 month*	*2 months*
Standard	91.0	87.9	84.7
Insecticide component of standard	75.2	71.1	57.5
Synergist component of standard	66.5	66.1	61.8
Experimental compound no. 1	70.5	62.2	51.2
Experimental compound no. 2	72.6	64.1	55.7
Experimental compound no. 3	69.7	63.0	51.0
Experimental compound no. 4	63.4	61.0	53.0
Experimental compound no. 5	52.7	54.5	48.5
None (check)	50 ± 1.8	50 ± 4.4	50 ± 1.2

During the development of the method, tests were conducted to study and evaluate the factors involved. Factors determined were: (1) the minimum number of insects per replication; (2) the minimum time lapse for the first reading; (3) the minimum changes of insects per test; (4) the effect of light on the distribution of test insects; (5) deviations from the 50% response on different test days; and (6) the numerical frequency of the distribution of test insects.

Minimum Number of Insects per Replication

To determine the lowest number of test insects that could be used in each arena to produce reliable repellency data, tests were conducted with untreated paper using 10, 20, 30, 40, or 50 test insects in each replication. All test insects were selected from the same population and introduced into the cylinder at approximately the same time. Distribution readings were made at 30-min. intervals until a total of five readings had been made. After each reading, the insects were mechanically disturbed and allowed to reposition before the succeeding reading was made. Comparisons were then made of the average deviation from the 50–50 distribution obtained with the different numbers of test insects.

Table II. Deviations from the 50% Response in Five Readings of Untreated Arenas Using Different Numbers of Test Insects

All tests were conducted in quadruplicate

Number of test insects per replication	*Reading*					*Average*	*Maximum*
	1	*2*	*3*	*4*	*5*		
10	0	8	2	2	5	3.4	8
20	1	12	21	10	1	9.0	21
30	10	6	27	7	8	11.6	27
40	6	8	6	5	4	5.8	8
50	1	7	6	4	1	3.8	7

The results (Table II) showed that increasing the number of test insects above 10 did not decrease the average deviation from the 50–50 distribution. Since the readings would be considerably more difficult to make if larger numbers of insects were used, there appeared to be no advantage to using more than 10 insects per replication.

Minimum Time Lapse for the First Reading

Tests to determine the minimum time between introduction of the test insects and the first reliable repellency readings were conducted using two series of untreated check papers and two series of papers treated with synergized pyrethrum standards. The test insects were introduced into the cylinders, and distribution readings were made after 5, 10, 15, 20, 30, 45, 60, 90, 120, and 1440 min.

Table III. Deviations from the 50% Response Obtained at Various Time Intervals with Insects on Untreated Paper; Averages of Two Tests in Quadruplicate

Series	*Minutes after introduction of insects*									
	5	*10*	*15*	*20*	*30*	*45*	*60*	*90*	*120*	*1440*
A	+4	−12	+9	−6	+10	+9	+3	−1	+5	−1
B	+8	−4	+3	−5	+4	+8	+1	+1	−5	0

Typical data are presented in Tables III and IV. The results obtained when the tests were conducted with untreated checks are shown in Table III. These showed that the readings did not level off to the 50 ± 5% range until 1 hr. after the introduction of the insects into the cylinder. The results obtained with the

Table IV. Deviations from the 50% Response Obtained at Various Time Intervals with Insects on Treated Standards; Averages of Two Tests in Quadruplicate

Series	Minutes after introduction of insects									
	5	10	15	20	30	45	60	90	120	1440
A	−1	+20	+ 8	+13	+13	+20	+23	+23	+30	+27
B	+3	+1	+16	+14	+16	+11	+15	+10	+25	+20

treated standards are shown in Table IV. In several hundred other tests with pyrethrum-treated paper from 75 to 80% of the test insects congregated on the untreated half of the arena. The data in Table IV show that the readings did not level off to the 75 to 80% range until about 1 hr. after the introduction of the test insects. Therefore, it was concluded that 1 hr. should be allowed between the time the test insects are placed on the repellency test arenas and the time of the first distribution readings.

Minimum Changes of Insects per Test

Tests made to compare the repellency data obtained when new test insects were introduced each day with the data obtained using the same test insects for the 5-day test period were conducted with paper treated with synergized pyrethrum. Eight strips of treated paper were joined to strips of untreated paper in the usual manner as described previously. Four repellency test setups, each in quadruplicate, were made using the same test insects for the entire test period, and four were made in which the test insects in each cylinder were changed each day during the test period. In the latter tests, distribution readings were made about 1 hr. after the introduction of the test insects in the early morning and again in the late afternoon. Both series of tests were conducted for two weeks.

Table V. Per Cent of Insects Counted on the Untreated Halves of Repellency Arenas When the Same Test Insects Were Used for the 5-Day Period and When the Test Insects Were Changed Daily

All tests were conducted in quadruplicate

Test week	Time of reading	Same test insects used all week		Test insects changed daily	
		%	Deviation[a]	%	Deviation
1	AM	93.6	−0.7	86.6	−0.3
	PM	98.5	+4.2	92.7	+5.8
2	AM	93.3	−1.0	79.5	−7.4
	PM	90.7	−3.6	88.0	+1.1
Mean	...	94.3	2.4	86.9	3 7

[a] Deviation from mean of all percentage values shown.

The comparative data obtained in repellency tests using new test insects each day and those using the same test insects for the 5-day period are presented in Table V. The results obtained with the same insects over a period of 5 days were as or more reliable than the results obtained in those tests in which new insects were used each day. Therefore, it was concluded that it would be more practical to use the same insects throughout the 5-day period.

Effect of Light on the Distribution of Test Insects

To study the effect of light on the distribution of the test insects on untreated paper, four untreated check setups were made in the usual manner but the tests

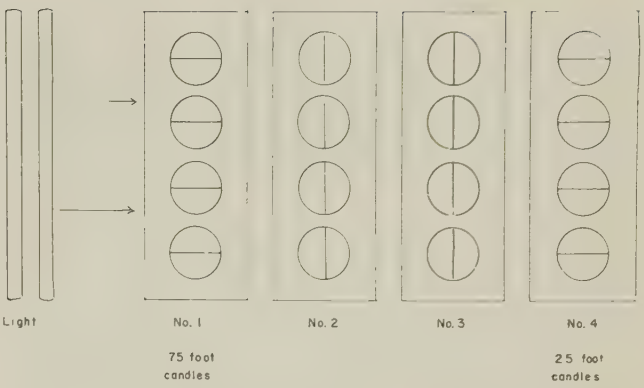

Fig. 2. Diagram of the setup of repellency test arenas to determine the influence of light on the distribution of the test insects

were conducted inside a light-tight enclosure. A unidirectional light source was placed at one end of the enclosure. This consisted of a desk lamp having two 15-w. daylight fluorescent bulbs with their long axes positioned approximately 10 in. above and parallel to the top of the table. The four test setups were arranged as shown in Fig. 2.

Each of the arenas was divided into two equal parts. The lines of demarcation of papers 1 and 4 were perpendicular to the long axes of the fluorescent bulbs, and those of papers 2 and 3 were parallel to the bulbs. Light meter readings of 75 foot-candles were obtained at the position of setup no. 1 and 25 foot-candles at the position of setup no. 4. The setups at positions nos. 1 and 4 would be considered the "checks," because light intensity on the two sides of the lines of demarcation in the arenas would be equal and approximately the 50-50 distribution of insects should be obtained. The setups at positions nos. 2 and 3 should demonstrate any influence of the light to either attract or repel the test insects.

Ten flour beetle adults were placed in each cylinder and hourly recordings made of their distribution for 6 hr. on two separate days. After each reading, the insects were brushed to the center of the arena so that they would reposition before the succeeding reading. The tests were repeated a second time, but the positions of setups nos. 1 and 4 were changed to those of nos. 2 and 3, and vice versa.

Table VI. Deviations from the 50% Response Obtained with Test Insects Exposed to a Unidirectional Light Source: Averages of Quadruplicate Tests

Week	Day	Position of demarcation line in relation to light source[a]			
		Perpendicular No. 1	Parallel No. 2	Parallel No. 3	Perpendicular No. 4
I	1	3	4	8	4
	2	7	10	0.7	3.5
II	1	12.1	1.5	8.3	5
	2	1.7	2.4	5.4	6.2
Av.		5.9	4.5	5.6	4.7

[a] Refer to Fig. 2.

The data used to determine the effect of light on the distribution of the test insects in untreated arenas are presented in Table VI. These data showed that on papers nos. 2 and 3, in which the lines of demarcation in the arenas were parallel to the long axes of the

fluorescent bulbs and repellency or attraction would have been demonstrated, the distribution of the test insects was within the 50 ± 5% range, just as was the case of papers nos. 1 and 4 in which such distributions were expected. There appeared to be no significant influence by the light on the distribution of the test insects.

Deviations from 50% Response on Different Test Days

For the comparison of the deviations from the 50-50 distribution in the readings made on the first test day with those in the readings made on the last test day, and also with the average deviation for the entire 5-day test period, data were selected from readings made on untreated check papers in a test conducted over a period of several months. Two check setups were used in each test, each one having four cylinders. The data shown in Table VII were recorded during 5 months of testing and involved five separate populations of test insects.

These data showed that the greatest deviations from the 50-50 distribution occurred on the first test day and the least on the last test day. But the average for the 5-day test period was less than for any one day. Therefore, it was concluded that the repellency figure should be based on the average of the daily readings over a 5-day period.

Table VII. Deviations from the 50% Response Obtained with Test Insects on the First and Last Days in Five Separate 5-Day Tests; Averages of Quadruplicate Tests

Test	*Days on which readings made* *First*	*Last*	*Average for 5 days*
1	5.0	12.5	6.3
	12.5	12.5	2.9
2	5.0	0 0	4.0
	7.5	5.0	5.4
3	5.0	5.0	2.5
	17.5	2.5	1.3
4	0.0	7.5	1.9
	5.0	8.5	0.3
5	7.5	2.5	3.6
	5.0	2.5	1.8
Av.	7.0	5.8	3.0
Max.	17.5	12.5	6.3

Numerical Frequency of the Distribution of Test Insects

The frequency of occurrence of each of the six possible numerical combinations of the 10 test insects in each replication was determined by selecting at random the data from the untreated checks for each of two groups of 10 weekly tests to indicate the minimum number of distribution readings needed. The number of times each combination occurred was determined and the total for the 10 weeks tabulated. Then the percentage of the total of 400 readings of each of the possible combinations was calculated. These are shown in Table VIII.

A study of the data showed that a larger number of the individual readings than would be expected on the basis of probability fell outside of the 50 ± 5% range. One of the reasons for the variation appeared to be due to the gregariousness of the test insects, as they were frequently observed to be in small groups. However, by running the tests in quadruplicate and making two readings each day for a 5-day period, the influence of this habit was corrected.

DISCUSSION

The desirability of developing laboratory tests was pointed out earlier in this paper, the results of which would tend to be indicative of the expected performance of experimental treatments under practical conditions. Various tests have been developed and are being used by several laboratories investigating insecticide coatings to accomplish these means. Practically all of these tests are based on toxicity or the prevention of insect penetration. Results presented elsewhere (Laudani *et al.* (*1*)) showed that the protection rendered by synergized pyrethrum was not primarily due to toxicity or directly to the prevention of insect penetration but was due to the repellent action of the coatings. Toxicity was lost within a few days after continuous exposure to light and air, but the protection rendered by the coating lasted from 9 to 12 months in semipractical field tests by Davis and Laudani (*2*).

The tests which have been devised to measure the effectiveness of coatings in preventing insect penetration when studied closely are nothing but indirect methods for measuring repellency. A good example of this is Method A adopted by the Technical Association of the Pulp and Paper Industry (*3*). Here treated papers are placed on the tops of half-pint Mason jars which are inverted in a media containing cadelle larvae. The results of the tests are based entirely on the number of penetrations obtained on the papers over a period of time.

Table VIII. Frequency of Occurrence of Each of the Possible Numerical Combinations of 10 Test Insects During 10 Weeks of Testing

Test	*Number of times each numerical combination was observed* 5–5	4–6	5–7	2–8	1–9	0–10
			Group A			
1	2	8	15	4	7	4
2	7	12	8	3	5	1
3	2	12	11	9	4	0
4	5	11	9	11	3	0
5	4	17	9	6	0	1
6	9	8	10	4	5	0
7	4	7	10	9	5	2
8	9	11	5	7	2	1
9	4	9	7	6	8	1
10	5	12	13	2	1	0
Total	51	107	97	61	40	10
Per cent[a]	12.75	26.75	24.25	15.25	10.00	2.50
			Group B			
11	7	17	10	4	2	0
12	5	16	12	3	3	1
13	4	6	11	8	4	5
14	5	12	9	8	4	0
15	9	6	9	9	3	1
16	6	7	11	6	6	1
17	5	12	9	7	3	0
18	7	13	6	4	5	1
19	4	8	8	3	4	8
20	6	12	7	7	2	1
Total	58	109	92	59	36	18
Per cent[a]	14.50	27.25	23.00	14.75	9.00	4.50

[a] Percentages not shown represent arenas in which less than 10 insects were observed. These values were discarded in this presentation.

A close study of this method will show that those papers which have the highest repellency will naturally prevent the insects from penetrating the papers. Therefore, since the primary interest is in measuring

repellency, it appears that the test should be devised to measure as accurately as possible repellency and nothing else. The method described was devised for this purpose and is submitted as a candidate for such a test. The fact is recognized that further study is needed and that more advanced mathematical treatment of the data is desirable. However, it is the hope that the presentation of the technique at the present time will stimulate sufficient interest that other workers will contribute to the further development of the test.

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Some Factors Affecting the Laboratory Testing of Packages for Resistance to Boring Insects

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The results of laboratory insect penetration tests on approximately 1000 piperonyl butoxide-pyrethrins treated cartons are analyzed. Some data on methoxychlor treated cartons are also given. Insects used were the cadelle larva, the adult saw-toothed grain beetle, and the adult lesser grain borer. The cartons were exposed in bins until penetrated. On the basis of correlation of the carton bin tests with panel penetration tests, it appears that it might be possible to develop a method of predicting field shelf life of experimental treatments by comparing their panel test performance with the performance of a standard treated carton whose field performance may be determined.

Insect penetration of food packages during distribution has long been recognized as a problem. Gray (*1*) has provided data gathered by one food manufacturer on the incidence of infestation in 3500 hot roll mix packages obtained by monthly sampling from retail stocks in the United States in 1949. Examination of these packages demonstrated a range of infestation from a minimum of 1.8% in February to a maximum of 19.0% occurring in the month of September. The over-all average for the year was 8.4%. To our knowledge, high rates of infestation such as this are not generally prevalent. One cereal products manufacturer has stated that their allowance for damage from all causes during distribution is less than 1% and that no record is kept of the contribution to this figure by spoilage from insect infestation. The distribution of dried fruits, on the other hand, is seriously hampered in some areas by the degree of infestation experienced at certain times of the year. Evidently then, some of the factors contributing to insect infestation of packages are subject to wide variations. Undoubtedly, important among these are the attractiveness of the product to insects and the activity of the local insect population.

In meeting the problem of infestation in local areas, the food producer has been faced with the choice either of developing special packaging for these regions or substantially abandoning distribution there. The task of developing any new packaging, not to mention packaging designed to meet so unpredictable a hazard as insect infestation, is a long and expensive one. The greater the degree to which packaging development problems can be worked out on a laboratory scale, the more economically and rapidly the development can be perfected. For this reason the ability to interpret accurately laboratory test results is most desirable. As the results of commercial experience are made available to an increasingly larger degree, a body of valuable empirical knowledge is being accumulated; however, the use of laboratory testing to obtain a more exact knowledge of the mechanism of insect penetration of packages is a field which still should not be neglected. Because of the large number of questions which are related to the chemical treatment of packages to render them insect resistant, it is most desirable to be able to work effectively with accelerated tests on small numbers of packages.

This paper describes tests which were carried out on over 1000 cartons. The cartons used represented several levels of treatment and they were tested at three different locations under varying exposure to insect attack. Panel penetration tests of the carton board were also run. Two different kinds of filling were used in the cartons tested. Some of the cartons contained white cake mix enclosed in a glued glassine bag type of inner liner. This package was relatively unattractive to insects as compared with the second type of carton tested which was a glued end shell type filled with corn meal.

In qualifying the chemical treatments used on these cartons to give insect resistance, several considerations must be taken into account. Although, ideally, the action of a protective treatment for packages need only be repellent and not toxic to the insect, all chemicals currently being considered for this purpose combine a measure of toxicity as well as repellency and, consequently, are generally classed as insecticidal. Because of cost and possible toxic hazard to the consumer, the choice of these chemicals for the treatment of food packages has been, so far, limited to those which are

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Table I. Experimental Cartons Used in Insect Penetration Tests

Treatment loadings given as milligrams per square feet piperonyl butoxide-pyrethrins

Carton designation no.	*Used in test*	*Method of board treatment*	*Estimated loading on board*	*Estimated loading added to ink*	*Estimated loading added to adhesive*
		Carton: 4 1/4 by 1 1/2 by 7 in., 0.022 in. Caliper, Clay Coated Board, Glue End, Glassine Bag Inner Liner, Cake Mix Carton, Filled with White Cake Mix			
1	1	None	Nil	None	50–5.0
2	1	None	Nil	8.0–0.8	50–5.0
3	1	Treated clay in coating	70–7.0	8.0–0.8	50–5.0
4	1	Oil emulsion added to clay coating	65–6.5	8.0–0.8	50–5.0
5	2	None	Nil	No printing	50–5.0
6	2	Calender coated oil emulsion	70–7.0	No printing	50–5.0
7	2	Calender coated oil emulsion	50–5.0	No printing	50–5.0
a	2	Calender coated methoxychlor emulsion	Undetermined[a]	No printing	50–5.0
b	2	Calender coated methoxychlor emulsion	Undetermined	No printing	50–5.0
		Carton: 4 by 1 3/4 by 5 1/2 in., 0.018 in. Caliper, White Lined Board, Glue End, Dried Fruit Carton, Filled with Corn Meal			
8	3	None	Nil	No printing	None
9	3	Calender coated oil emulsion on outside carton surface	50–5	No printing	None
10	3	Calender coated oil emulsion on inner carton surface	50–5	No printing	None

[a] Believed to be 50 to 100 mg./sq. ft.

relatively low in killing power against insect populations. Moreover, other testing which is not being reported here has indicated that, in some cases, even where treatments having an extremely high degree of killing power were used, significant infestation of packages can still occur. It must be recognized then that if an insect remains active long enough to penetrate a package, even though in contact with a 2 hr. lethal dosage for example, repellency is still an important factor to be considered. For these reasons then this paper is reporting the results of tests on cartons with pyrethrins-piperonyl butoxide treatments at treatment levels in the neighborhood of 5 mg. of pyrethrins and 50 mg. of piperonyl butoxide per sq. ft. Data on two sets of cartons treated with methoxychlor at a similar level of activity are also being reported in connection with one series of tests because it is believed that the activity of all cartons present in the test enclosure is significant, and should be taken into account in interpreting the test results.

PREPARATION OF SAMPLES

The several types of cartons used in these tests are described in Table I. As can be seen from this table, the cartons designated as 1, 2, 3, and 4 were printed, clay coated cartons. Cartons 5, 6, and 7 were identical in construction with the 1 through 4 cartons except that they were not printed. Cartons 8, 9, and 10 were plain, unprinted cartons of the type used in dried fruit packaging. The clay coated board used for these cartons was treated in two ways. In one case the insecticide was added either in the form of a treated carrier clay (carton 3), or in the form of an oil emulsion (carton 4), to the clay coating itself; or in the second case the insecticide was coated over the clay coating at the calender rolls as an oil emulsion (cartons 6 and 7). The clay coating was done on the board machine at two stations giving a total loading of pigment solids of 2 1/2 lb. per 1000 sq. ft. The color pigments used were conventional clay and titanium pigments with a casein adhesive as coating binder. The board for the white lined cartons was standard white lined stock and the insecticide was applied to the board as an oil emulsion at the calender rolls.

In addition to estimating the loading of insecticide applied to the board used for these cartons by material balances on the consumption of coating during the machine run and, in some cases, by tracer analysis on the coated board, the concentration of piperonyl butoxide in the board was determined for some of these boards by the method of Jones, *et al.* (*3*). Table II gives the results of these analyses as well as those of some hand-coated samples prepared in the laboratory. It can be seen that the agreement between the applied and recovered loadings of piperonyl butoxide is not good.

In addition to the analyses performed on these samples, assays were made on 23 other experimental ma-

Table II. Recovery of Piperonyl Butoxide

Carton designation no.	*Method of application*	*Loading applied mg./sq. ft.*	*Loading found, mg./sq. ft.*
	Machine Coated Board		
3	Treated clay in coating	70	28
4	Oil emulsion in clay coating	65	22
7	Oil emulsion over clay coating	50	12
	Hand Coated Board		
	Oil emulsion over clay coating	45	33
	Treated clay over clay coating	55	30
	Treated clay over clay coating	50	45

Table III. Surface Activity of Insecticide-Treated Board Against Confused Flour Beetles

Five beetles per sample, 20–40 replications

Equivalent carton no. from Table I	*Board*	*Average % knockdown after hours of exposure shown* 1–6	24	72	120	240
8	White lined, no treatment	4	0	0	0	16
5	Clay coated, no treatment	12	6	6	14	41
3, 4	Clay coated, treated	25	70	55	65	83
3, 4	Clay coated, treated, aged 8 months in piles	24	33	49	58	..

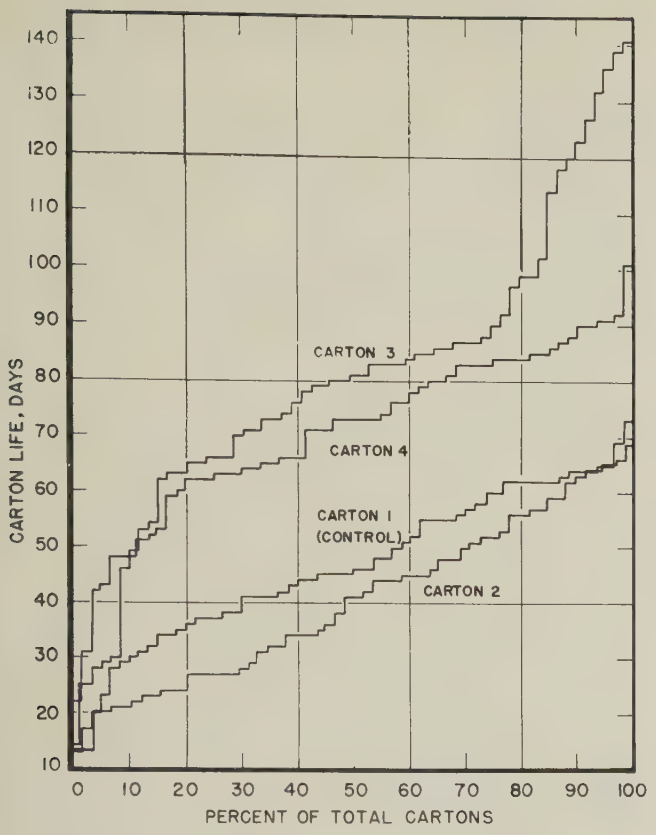

Fig. 1. Penetration of piperonyl butoxide-pyrethrins treated cartons by boring insects—test one

chine-coated boards where the insecticide had been applied both in the coating and at the calender rolls. From the results of these analyses, the following formula was derived: (*applied loading*/2.5)-10 = *amount assayed* where the units of loading are milligrams per square foot. In the case of the data cited in Table II, which were not used in deriving this formula, the formula fits more closely if a divisor of 2.0 is used instead of 2.5; however, it can be stated that, in general, it was impossible to recover more than half of the piperonyl butoxide applied by machine coating techniques. With hand-coated samples prepared in the laboratory, the recovery ratio was somewhat improved; however, even in the case of clay carried insecticide, hand coated on clay coated board, we were unable to duplicate the recoveries reported by Incho, *et al.*, (*2*) on kraft paper. With respect to the possible further loss of piperonyl butoxide by aging after the initial assay, a series of repeat analyses were run on several sets of samples over 100-day periods and no significant loss was found. It may be concluded, therefore, that the majority of the disappearance of the piperonyl butoxide which has been observed here has occurred at the time of the coating operation, or shortly thereafter, before the chemical assay could be run.

Even though the analytically determined loadings of piperonyl butoxide are at wide variance with the applied loadings, assay of the board surface activity by the knockdown of confused flour beetles indicated that coated samples analyzing between 20 and 45 mg. per sq. ft. all had approximately the same activity against confused flour beetles. These tests were performed by fitting a board sample in the bottom of a 90 mm. glass petri dish. The dish was set upright and five beetles were placed on the board in each dish. The test result reported is the average of the results for 10 replicate samples. Any beetle which was not on all six feet and moving normally was reported as "knocked down." A further distinction is normally made between those insects which are definitely dead and those which are only partially paralyzed but the loadings used on these boards were such that no significant amount of mortality was produced. The averaged results of these tests are given in Table III for both the initial board activity and the activity of the treated board after 8 months' aging in piled storage. This aging caused some reduction in the knockdown at 24 hr. insect exposure but little reduction in knockdown at 72 to 120 hr. The higher percentage of knockdown on the clay-coated blanks as compared to the white lined board can be attributed to the fact that it is more difficult for the insects to keep their footing on clay-coated board. The increase in knockdown on the blanks between 120 and 240 hr. is probably a fatigue condition. Incho, *et al.* (*2*) report somewhat greater knockdowns on red flour beetles for treatments at this dosage level on kraft paper; however, it should be noted that in their method the petri dish is inverted over the board sample so that the insect is in a confined atmosphere. Under these conditions the degree of volatilization of the insecticide, even though undetectable by chemical methods, may have an effect on the test results.

The insect knockdown tests and chemical analyses described above were reported for the purpose of characterizing the treatments, which had been produced on these samples, by tests which could be run relatively easily and rapidly. The completion of the penetration tests which are being reported required as long as 430 days in one case and except in the case of the panel penetration tests required finished cartons. Although the resistance of a board to boring insects may not be comparable to beetle knockdown activity, it is generally desirable to establish some level of activity by this test before proceeding with the extensive amount of work involved in a carton penetration test.

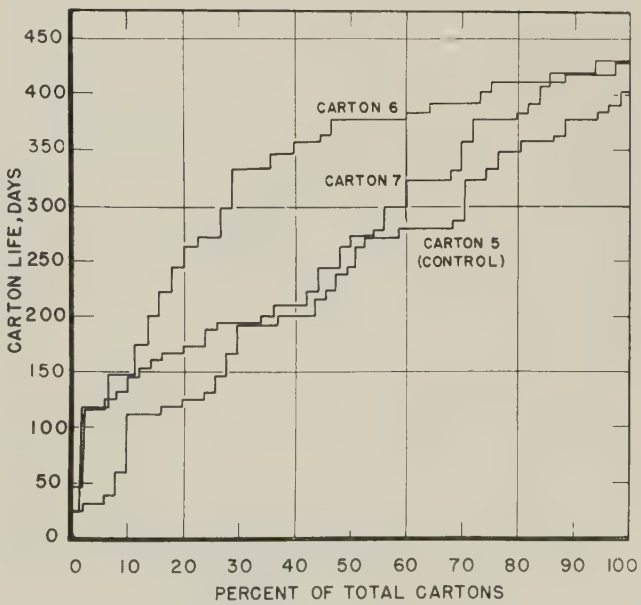

Fig. 2. Penetration of piperonyl butoxide-pyrethrins treated cartons by boring insects—test two

PENETRATION TEST METHODS

For the principal testing being reported here on the penetration of cartons by boring insects, the method of exposure of the cartons to insect penetration was as follows: cartons were selected at random from a supply of each type to make up series. In the first test, a series consisted of six each of four types of cartons. Each of the six cartons of a single type was laid on a different side so that all sides were exposed to attack. The procedure for carrying out the penetration tests on the cartons was similar to Method A of TAPPI Standard T 473m-47 (*4*). The cartons were placed in steel bins containing grain infested with saw-toothed grain beetles, lesser grain borers, and cadelle larvae. The bins were held at ambient room conditions. In the space available, ten series of cartons, no. 1, 2, 3, and 4, were used or a total of 240 cartons. Six bins were used, each containing one series of 24 cartons and 16 additional cartons from another series for a total of 40 cartons per bin. Thus, each type of treatment was exposed on each side ten times in the entire test. Cartons were examined daily except on week ends and removed when penetrated. In the second test, cartons 5, 6, and 7 and two methoxychlor treated cartons were tested using a total of 300 cartons in the same kind of arrangement as the first test.

In the third test, cartons 8, 9, and 10 were used. These cartons were arranged in six bins as follows: bins 1 and 3 contained confused flour beetles and saw-toothed grain beetles. Bins 2, 4, 5, and 6 contained saw-toothed grain beetles, lesser grain borers and cadelle larvae. All bins contained two types of treated cartons, 9, 10. Bins 1, 2, 5, and 6 had blanks, 8, as a third type of carton in addition. Thus, in bins 1, 2, 5, and 6 there were 13 sets of three cartons each, and in bins 3 and 4, 20 sets of two cartons each. The cartons were examined at 3 to 4-day intervals and penetrated cartons replaced weekly on a schedule designed to show whether a difference in rate of penetration existed between bins where cartons were removed as soon as penetrated and bins where only one set of cartons was changed at a time. Whereas, in the first two tests the number of cartons in the bins were progressively reduced as penetrated cartons were removed, in the third test all cartons which were removed were replaced with a replicate carton from the original supply of test cartons so as to maintain a constant number of cartons in the bins.

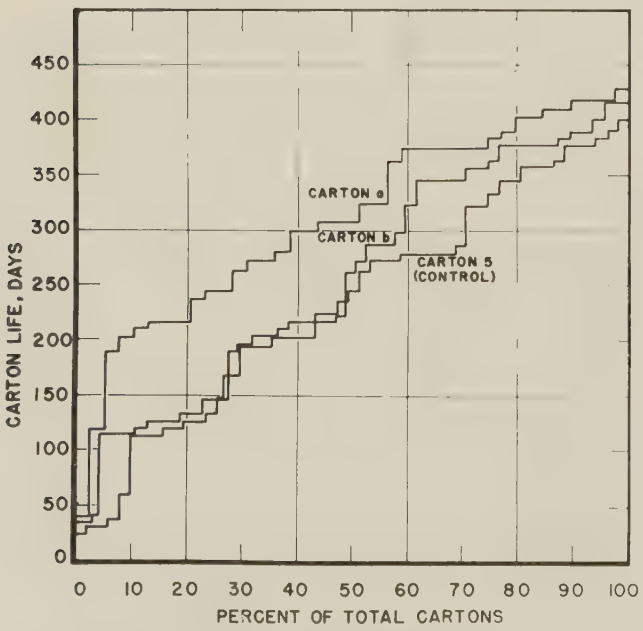

Fig. 3. Penetration of methoxychlor treated cartons by boring insects—test two

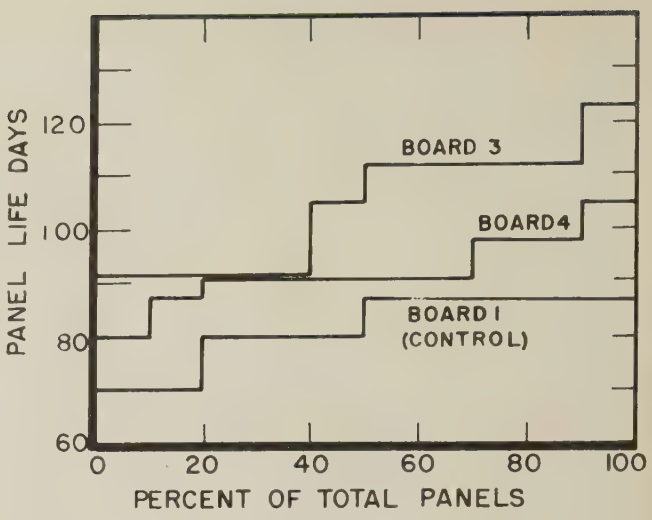

Fig. 4. Penetration of panels corresponding to test one

The results of the bin storage tests on cartons 1 through 7 are given in Figs. 1, 2, and 3 which are plots of the times to penetration for all of the cartons examined. In the first test on cartons 1 through 4, all but three of the 240 cartons are reported; but in the second test on cartons 5 through 7 and a and b, because of the extended duration of the test, it was terminated after 51 blanks had been penetrated and the penetrations for the other cartons corrected to that basis. The data for the piperonyl butoxide-pyrethrins treated cartons run in the first test are given in Fig. 1 and those for the second test in Fig. 2. Figure 3 gives the data for the blank, 5, and two sets of methoxychlor treated cartons designated as a and b which were also present in the bins in the second test. The level of treatment and protection afforded by these cartons was comparable to that of the piperonyl butoxide-pyrethrins treated cartons. The results of the third bin test on cartons 8 through 10 are given in Table IV. The average carton lifetime in days for the cartons in bins 1 through 5 is calculated. The lifetimes in bin 6 were unaccountably longer and were not averaged in.

In addition to the penetration tests run on the cartons, panel penetration tests were run on samples of the board used in cartons 1, 3, 4, 5, 6, and a. The penetration tests were conducted in a manner similar to the procedure described in Method A of TAPPI Standard T 473 m-47 (*4*). In our tests, the mouth of a half-pint mason jar was covered with a disk of the sample to be tested and held in place by the threaded screw ring supplied with the jar. The inverted jar was placed in the same bins used for the carton tests, but not necessarily concurrently with the corresponding carton tests. The samples were inspected at weekly intervals. The results of these tests are plotted in Figs. 4 and 5.

DISCUSSION OF TEST RESULTS

The data plotted as shown in Figs. 1 to 5 represent

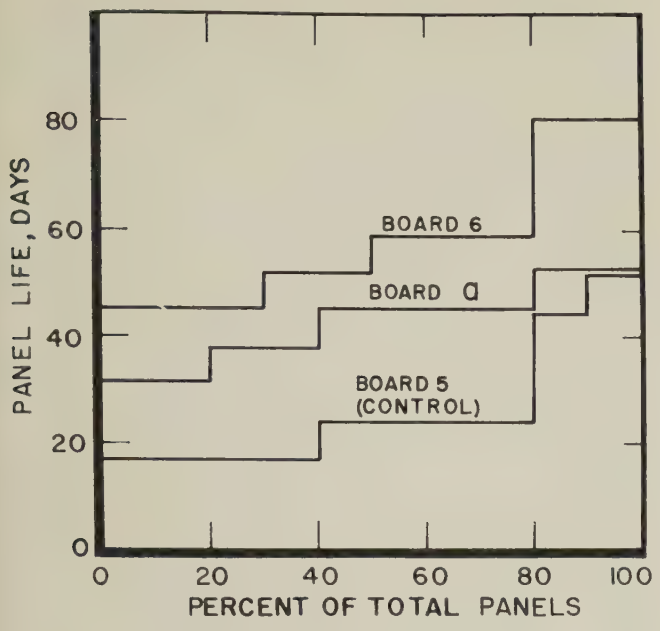

Fig. 5. Penetration of panels corresponding to test two

the gross carton-days' life for the cartons tested. By comparing the area under the curve for a treated carton with that of the blank, a measure of the relative protection afforded by the treatment is obtained. The ratio of the gross carton-days' life for a treated carton over the carton-days' life of the blank is defined as the *penetration ratio*. Table V gives these ratios, computed from the data of Figs. 1 through 5, for the cartons and panels. In order to relate conclusions based on the use of the penetration ratio to the mechanism of insect attack taking place in these tests, some qualifying assumptions will be made. It can be stated that the purpose of laboratory penetration testing is to compare the resistance of a treated sample with the resistance of a standard sample under the same degree of insect penetration attack. As long as all of the test samples are present in the bins in substantially equal numbers, it may be reasonably assumed that they are all subject to equivalent insect attack. If, however, the supply of one or more types of sample becomes exhausted through penetration, and subsequent to this point the rate of penetration of the remaining cartons alters significantly, then the question is logically raised as to whether the performance of the cartons remaining can be legitimately compared with those penetrated prior to this time. In this presentation it has been assumed that this comparison could be justified. In order to do this the following assumptions were made:

1. The penetration of the samples which apparently occurred only after a large proportion of the comparative samples was exhausted was in reality under way throughout the entire period.

2. The spectra of insect penetration activity, that is, the relative numbers of highly active as compared with less active insects, is the same for all the cartons tested. Thus the time to penetration in each carton percentile is a measure of resistance to a level of insect activity which is equal in the same penetration percentile of every other type of carton.

According to the penetration ratio shown in Table V, carton 2, which contained insecticide in the ink and flap adhesive only, was apparently 15% less effective than the blank. It may be, however, that this amount of spread is within the precision of the test. On this basis, therefore, there is no significant difference shown in column 5 of Table V between cartons 3 and 4, among cartons 5, 7, and b, and between cartons 6 and a. On the basis of the penetration ratios reported in column 5, the three most effective cartons tested, 3, 4, and 6, showed an average increase in carton life of 50% as compared to the blanks. In column 9, penetration ratios are given for the panel tests on these same board samples.

In Fig. 6, the correlation between the carton and panel penetration ratios has been plotted. Since the lines for the data from the two different tests do not agree at all closely, the correlation between the panel test and the carton test is obviously generally unreliable. It is very interesting to note, however, that for the two tests performed the correlation between the effectiveness of the treatment on cartons, as compared to the panels, indicates that the precision of the results may be quite good and considerably better than the 15% figure which has been suggested above in comparing the results for cartons 1 and 2.

It should be noticed that the lines for the two tests fall almost equidistant from, and on opposite sides of, the 45° line. This is probably due to variations in the general level of insect activity between the carton and panel tests. In test 2, the level of insect activity during the carton test was relatively lower than that at the time the panels were exposed in the bins. In test 1, on the other hand, the level of insect activity was higher during the carton test period causing the correlation line to fall on the other side of the 45° line. In view of the demonstrated eight-fold variation in insect activity, the coincidence of an experimental correlation with the 45° line would appear to be a highly unusual case, therefore. It is most important to note, however, that in order to obtain the straight line correlations shown in Fig. 6, the proportions of the penetration

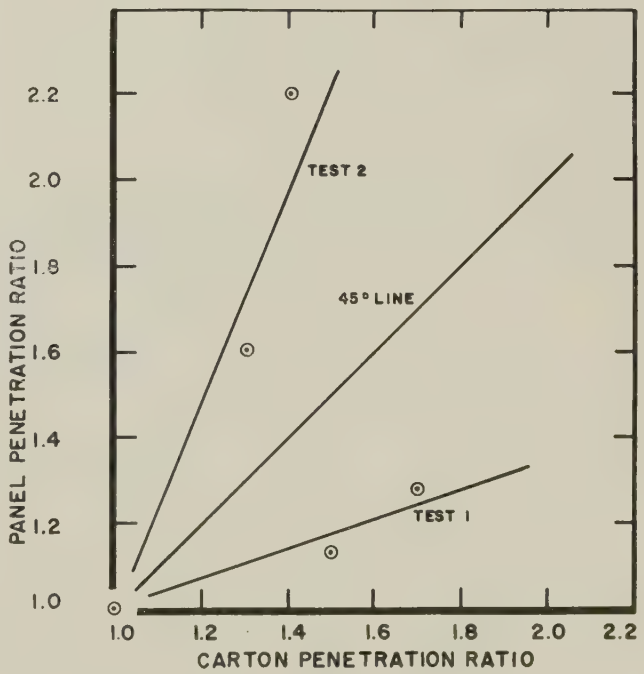

Fig. 6. Correlation of carton and panel tests by comparison of penetration ratios (data from Table V)

Table IV. Penetration of Cartons Filled with Corn Meal

Cartons 8, 9, and 10 as shown in Table I examined at 3 to 4-day intervals for 21 days

Test bin	Replacement schedule	Total cartons exposed	Average carton life, days, of carton numbers 8	9	10
1	Set of 3 per week	45	5.0	7.2	7.2
2	Weekly as penetrated	92	5.1	7.9	11.5
			4.4	8.3	7.6
			4.4	7.0	
3	Set of 3 per week	44	None used	8.7	9.1
4	Weekly as penetrated	58	None used	14.1	11.1
				7.0	10.1
5	Weekly as penetrated	82	5.6	8.8	8.9
			7.2	11.2	6.2
			6.2		
	Average—bins 1 through 5		5.4	8.9	8.9
6	Not replaced	39	12	16.8	17.8

ratios of the panels to each other must be the same as those for the penetration ratios of the cartons to each other. Thus, although the angle of intersection of the correlation line with the coordinates at the origin may vary, the distance of the points from the origin should always remain the same. This suggests that for adequate evaluation of an experimental sample it should be tested not only in conjunction with a blank but with a standard treatment as well.

A further indication which appears from these data is that the lower insect activity and, consequently, the longer exposure time in the second test may be due to the volatility of methoxychlor which being denser than air would tend to concentrate in the bins which were open only at the top; however, this cannot be confirmed by these data. For more exact results, a method of comparing the rate of attack on cartons treated with chlorinated insecticides with attack on blanks which are not exposed to possible vaporization of the insecticide should probably be considered. There is no evidence to indicate that the presence of pyrethrins treated cartons causes any reduction of insect activity on the blanks, however. There is a definite indication that attack on clay coated board is relatively slower than on noncoated board. This is probably due, to some extent, to the fact that the insects can get a better foothold on uncoated board. Possibly differences in color and edibility also have an effect.

The fact that the third series of tests, in which full bins of cartons were maintained, showed approximately the same ratio of protection, 1.65, between treated and untreated cartons as in the first two tests tends to show that the rate of attack on a single carton is independent of the number of other cartons in the bin. It is suspected that the greater rapidity of penetration in the third test was due to two things:

1. The uncoated cartons were relatively easier to get a foothold on.
2. The corn meal filling was essentially more attractive than the cake mix and was, furthermore, not contained in an inner glassine liner, which probably restricts the escape of attractive odors.

Since the species of insects found in the penetrated cartons were also recorded, the experimental data were examined to ascertain whether any differences in activity with respect to species could be shown. It was found that 85 to 95% of the cadelle larvae penetrations had occurred on a corner or edge of the carton. In the case of the saw-toothed grain beetle, there was some indication of a preference for edges and corners but in a ratio not greater than two to one. The lesser grain borers did not show any preference in this test. With respect to the relative activity of these three species in tests 1 and 2, it appeared that approximately 70% of the cartons were penetrated by saw-toothed grain beetles, 40% by lesser grain borers, and 20 to 30% by cadelle larvae. The higher figure given for cadelle is for the blanks since there seems to be some indication of a difference between the results for the blanks and treated cartons in the case of cadelle. These percentages are the values for each species regardless of whether the carton had also been penetrated by another species during the time elapsing between inspections.

In addition to the tests reported above, a further test of the bin type on the cake mix cartons was run at a second location. In this test, four replicate series of cake mix cartons consisting of four treated cartons and three blank cartons, numbers 1, 3, 4, 5, 6, 7 in Table I and a blank obtained locally, were exposed on shelves contained in a 50-gal. fiber drum to five species of stored products insects—lesser grain borer, saw-toothed grain beetle, confused flour beetle, flat grain beetle, and cadelle larva. Sets of cartons were removed for examination at seven-and twelve-month intervals. After 7 months in the drum, there had been no significant penetration of the cartons. Examination of two sets at the end of twelve months showed that although only two of 14 cartons had been perforated, 50% of the treated cartons and 83% of the blanks were infested. Thus, in all but two cases the insects must have entered the carton through the flap closure. By

Table V. Penetration Ratios of Treated Samples as Compared with Blanks

Carton days/carton days

Carton no. from Table I	Carton: Data from figure	Carton: Duration of test, days	Carton: Number of cartons penetrated	Carton: Penetration ratio	Panel: Data from figure	Panel: Duration of test days	Panel: Number of panels penetrated	Panel: Penetration ratio
				Test 1				
1	1	73	60	1	4	87	10	1
2	1	69	58	0.85	..	..	..	..
3	1	141	59	1.71	4	123	10	1.27
4	1	101	60	1.50	4	105	10	1.13
				Test 2				
5	2, 3	402	51	1	5	52	10	1
6	2	430	45	1.40	5	81	10	2.21
7	2	430	50	1.15	..	..	..	..
a	3	430	39	1.32	5	52	10	1.61
b	3	419	47	1.09	..	..	..	..

count of the insects present inside the cartons, the treated cartons showed definite evidence of repellency on the part of both the treated glue and treated board.

SHELF STORAGE TESTS

Simulated shelf storage tests were also run at two locations with the cake mix cartons. At each location a series of blanks and treated cartons were put on open shelves and subjected to insect contamination. The cartons were exposed to stored products pests including flat grain beetles, lesser grain borers, saw-toothed grain beetles, and confused flour beetles. After 7 months at one location, no evidence of penetration of the carton walls had appeared. However, five out of seven cartons were infested. The insects had evidently entered through the flap closures. Of the seven cartons exposed, two of the three blanks were heavily infested and one free of infestation, and three of the four treated cartons had insects which had entered through the seal and had not penetrated the glassine liner. In the second location, a staggered schedule of case storage followed by shelf storage was followed for a five-month period. No penetrations occurred during case storage and of 80 treated cartons exposed on shelves, two were infested. Of 120 blanks exposed, seven were infested.

CONCLUSION

To summarize the results of this analysis of laboratory testing of paperboard packages for resistance to penetration by boring insects, it appears that under the degree of insect pressure to which a carton is exposed in the bin type of test, insect attack is general and continuous. Numerous partial penetrations are in progress on a single carton at the time the first complete penetration is found. This indicates that there is some variation in the rate at which insect attack proceeds on a single carton. The further fact that in the complete array of cartons there is also a variation in the time to penetration among the individual cartons suggests that this is merely a more detailed picturization of the process of attack which takes place on the individual carton. Thus it may be concluded that a comparison of the composite carton-days' life for a treated carton versus its control carton represents its relative resistance to insect penetration under the conditions of the test.

It further appears from Fig. 6, as discussed above, that if two or more levels of treatment are compared with a blank either by a panel or a bin test that the same relation between these values might be expected to be preserved in any future tests regardless of the absolute values of the ratios. Thus, if a treated board tested 1.2, 1.5, and 2.5 in panel, bin, and shelf tests respectively, a treated sample testing 1.5 in the same panel test should test 1.87 and 3.12 in the corresponding bin and shelf tests respectively. Therefore, if a standard insect resistant carton could be established and thoroughly evaluated by field tests, any number of additional experimental treatments could be evaluated merely by comparative panel testing with the standard and a blank.

For such a standard, the possibility of preparing a relatively stable nonvolatile insect resistant treatment of intermediate lethal activity should be explored. Such a standard need not be a permanent standard but should be one whose preparation and properties can be precisely duplicated.

It is believed that further work to verify the possibility of establishing such a standard could be profitably undertaken and that if this were to be successful, an easy and accurate method would be available for predicting the resistance to penetration of new insect resistant treatments on the basis of laboratory panel testing.

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The Identification of Digester Corrosion Conditions and Methods for Their Prevention

LOUIS A. DELA GRANGE

The identification of types of loss of metal in wood pulping digesters, their causes and cures used to extend the useful life of the vessel. The information contained in this report was compiled from experiments on 45 digesters. To show that the useful life of wood pulping digesters can be extended, of these 45 digesters, 17.8% have been in service 30 years; 22.2%, 17 or more years; 33.4%, 24 or more years; and 53.4% 16 or more years, the balance of which have been installed since 1937 without the need of replacing any in the near future.

THE purpose of this paper is to try to establish a means of identifying the loss of metal on the inside surface of wood pulping digesters and some corrective measures that have been taken.

This loss of metal, commonly called corrosion, is due to one or more of the following:

1. Chemical attack due to the strong cooking liquor, whether acid or alkaline, acting as an electrolyte

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Fig. 1. Light pitting

between dissimilar metals, these dissimilar metals being found within a given area of a single plate as well as two metals of different chemical composition. It has been proved by Edward W. Hopper of Crucible Steel Co. (*1*) and John Hassler of West Virginia Pulp & Paper Co. (*2*) that a flow of current does exist between the rim and the core of a rimmed steel vessel in the presence of an electrolyte such as cooking liquor.

2. Impingement or erosion is caused by uncontrolled flow of liquor or chips against the inside surface of the vessel.

The figures will illustrate some of the types of loss of metal that have been found in digesters.

LIGHT PITTING

Figure 1 is the corrosion that was present in a NSSC digester. It is termed as light pitting and if allowed to continue will be deep pits. The term corrosion was used because the attack is general and has no definite pattern. The cause was thought to be galvanic attack due to the mill scale being present and possibly the liquor adjacent to it becoming acid at times. After sand blasting to remove the scale the attack continued and the wasted away areas had to be overlayed with type 310 stainless steel. This procedure was developed by E. W. Hopper (*3*).

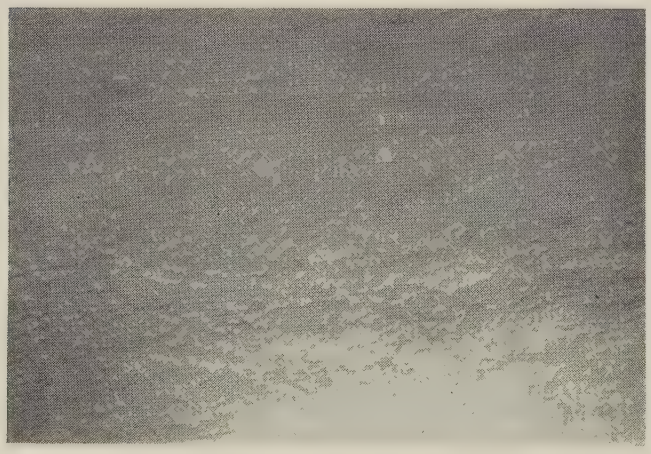

Fig. 2. Light pitting corrosion and erosion

The combination of corrosion and erosion in a digester used for cooking kraft pulp shown in Fig. 2 is also termed as light pitting.

This type of loss of metal appears to be due to the chemical attack of the strong liquor but the product of the attack which would help to prevent further loss of metal is washed or scrubbed away by the movement of the liquor and chips within the vessel leaving the area open to further attack. The difference between the low area and the higher areas is usually $^1/_{32}$ to $^1/_{16}$ in.

The over-all pattern of the islands of this loss of metal is usually in the direction to the flow of liquor and chips in the digester. This can be seen as plateaus running from the top to the bottom of the photograph. This flow may be due to the natural circulation of liquor caused by the steam being admitted at the bottom of the vessel or by the forced circulation of liquor by pumping from the bottom to the top of the vessel for the purpose of wetting or packing the chips.

Fig. 3. Channeling

This type of loss of metal can be prevented by the installation of deflectors on the side wall. These deflectors will be described later.

GROOVING OR CHANNELING

Figure 3 is a photograph showing the vertical grooves or channels cut in the digester wall by the liquor flowing through chips at the side wall.

The most frequent cause of this type of erosion is the chips falling into the digester at an angle which will pile higher on one side than the other. These sloping chips will direct the incoming liquor to the low side causing it to channel down between the less densely packed chips and the side wall.

The second cause may be that the circulating liquor spray ring around the circumference of the inside of the digester may pour the liquor down the side wall rather than in the center of the chips as it should for good chip packing and wetting.

If when charging a digester the strong cooking liquor is permitted to run down the side of the digester the same channels are present.

This channeling or grooving can be prevented by the following means: (1) by having the discharge opening in the chip bin on the center line of the digester, (2) by having the liquor filling spout so its flow is into the apex of the chip cone, (3) by having the flow of liquor from the circulating liquor spray nozzle downward into the apex of the chip cone, (4) by having deflectors on the side wall to diffuse the liquor into the chips rather than let it run down between the digester wall and the chips.

GROOVING BELOW FITTINGS

Figure 4 is a photograph showing the loss of metal below an opening in a digester wall for a pressure gage connection. The gage on a panel is connected to the digester by a long pipe which traps chips and liquor during the time the digester is under pressure. After the pressure on the vessel has been relieved, the liquor that was trapped in this pipe will gradually seep out and run down the side wall. As this wall is of higher temperature than the liquor, some of the liquor will evaporate,

Fig. 4. Grooving below fitting

thereby increasing chemical concentration. This is sometimes referred to as hot plate boiling as reported by Flynn, Richter, and Snyder (*4*).

Figure 5 is a photograph showing the effects of chips and liquor building up on the upper side of a fitting extending beyond the inside wall of a digester. The liquor draining from the chips will cause a loss of metal eventually as shown in Fig. 4.

This type of loss of metal may be prevented by the following: (1) extending the fitting beyond the inside wall at a downward angle, (2) installing a drip shield or deflector below the fitting so the liquor draining from the chips will drip from the shield away from the wall, (3) blank off flush with inside digester surface.

ISLANDS

Figure 6 is a photograph showing islands of metal in an otherwise well-worn, light pitted area.

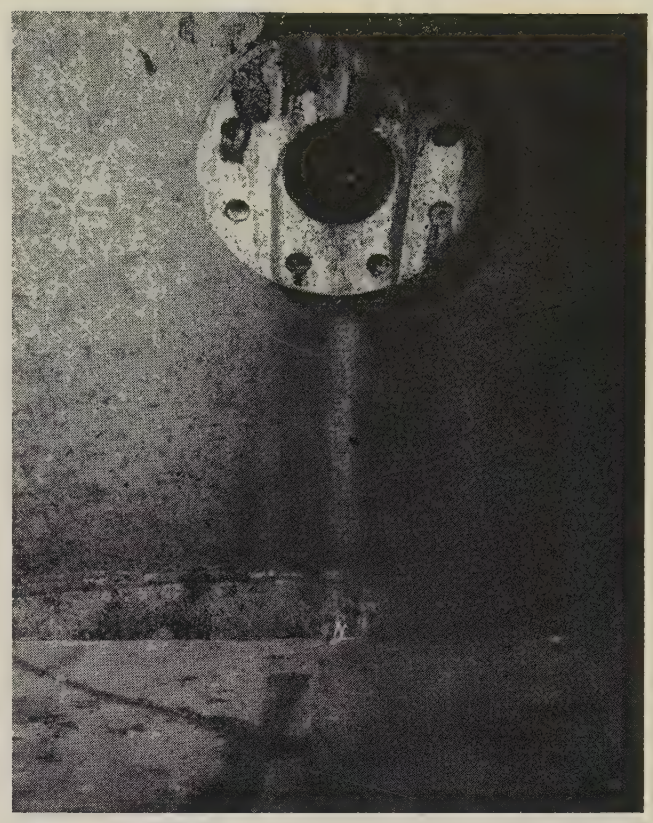

Fig. 5. Grooving below due to chip build-up on fitting

These areas appear to be caused by steel that is less susceptible to attack than the surrounding areas.

It is thought that these areas are caused some time during the rolling of the steel plate as they always appear in strings in the direction of rolling of the plate.

The only prevention of these islands is to prevent the wall from wasting away.

WASHING

Figure 7 is a photograph showing the effect of liquor washing from the head of a digester down the side wall.

It will be noted that the light area under the circulat-

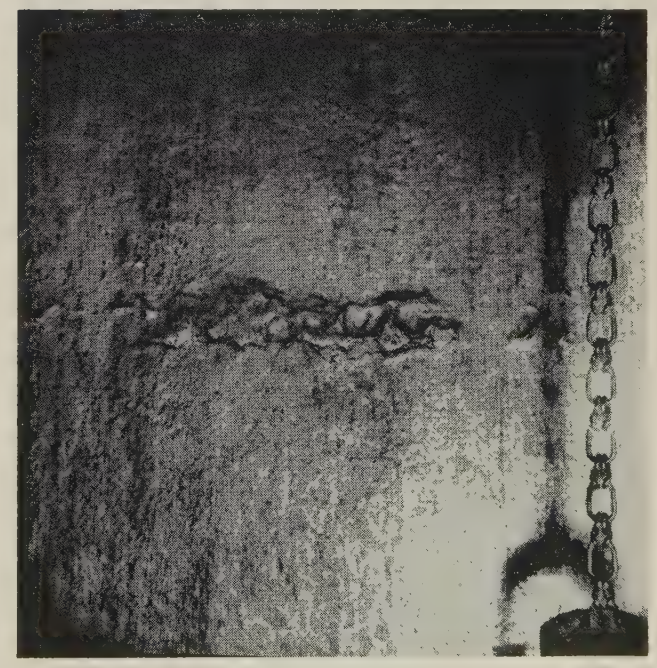

Fig. 6. Islands

Fig. 7. Effect of washing

ing liquor spray ring is bright, shiny, and bare metal with a scale forming approximately 2 ft. 6 in. below the girth weld (washer spacing 2 ft. 0 in.), also on the circulating liquor spray ring.

This washing was thought to be caused by the liquor or the condensation from the foam bubbles bursting on the head and flowing down the inside surface of the head.

To prevent this washing, a 2 in. wide deflector was welded perpendicular to the head above the circulating liquor spray ring.

Figure 8 shows the same area as Fig. 7 approximately 3 months after the deflector had been installed. This area behind and under the pipe is covered with a tight adhering, carbonate scale. It is interesting to note that the circulating liquor spray ring has lost its scale. This is apparently due to the liquor dropping from the deflector onto the ring.

Figure 9 shows the washed area on the side wall of a digester. To prevent this washing a 2 in. wide deflector was installed 45° to the side wall. Not being sure of whether the liquor circulation in a digester was up the side and down the center or up the center and down the side, the deflector was installed for the former flow. This was incorrect because had the flow been up the side, the scale would have been above the deflector rather than below it.

Figure 10 shows the same area as shown in Fig. 9 except the second deflector was added 2 ft. 3 in. above the first and corrected for down flow at the wall.

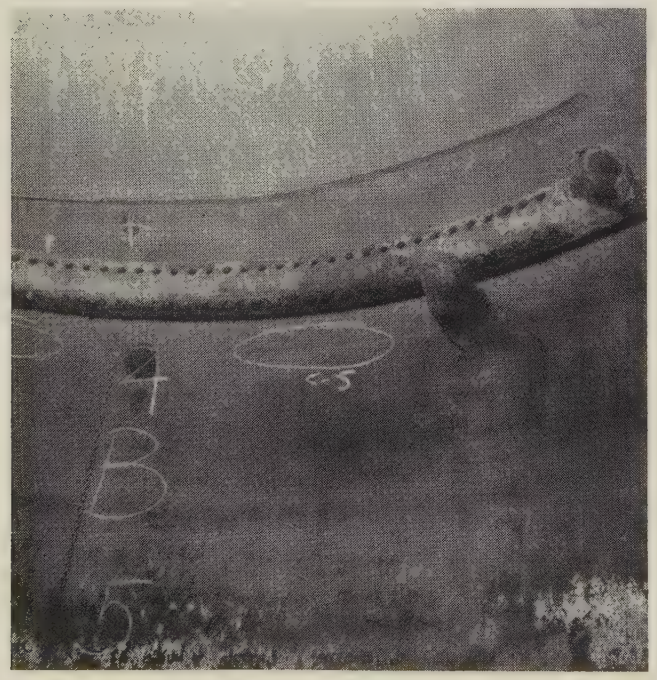

Fig. 8. Build-up of scale after adding deflector

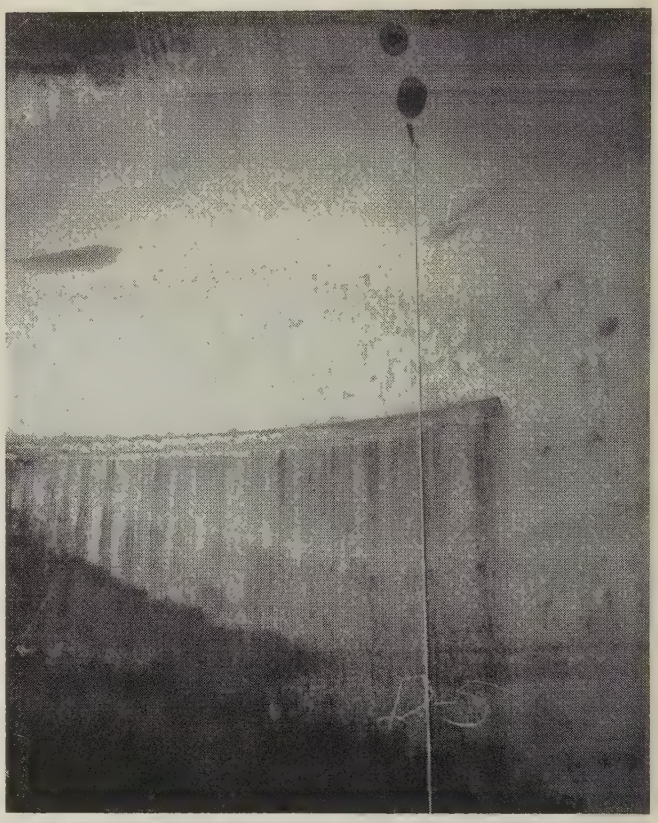

Fig. 9. Effect of washing sidewall

This washed area was covered with a carbonate scale after approximately 3 months of service. There were no other changes made in the method of charging, processing, or types of wood cooked.

IMPINGEMENT

Figure 11 shows the effects of chips and liquor impinging on a digester wall. This graph was plotted from Audigage readings of horizontal grid no. 11 of four different digesters during one round of digester inspections.

With an original thickness of 1.344 in., it can be noted there is an over-all loss of metal at vertical grids B and C, but that the greatest loss of metal is on grid F.

This great loss of metal can be attributed to the chips striking the side of the vessel as shown by the repose angle of the chips. The chips strike the wall at G and cascade to a lower level at D. This is caused by the chip bin opening being off center line of the digester.

At the same time that the digester is being charged with chips, the strong cooking liquor is carried by the chips to the side wall where the strong liquor is further concentrated by the hot digester wall evaporating the

Fig. 10. Scale build-up on sidewall

liquids, thereby increasing the chemical concentration or hot plate corrosion.

This condition is further aggravated because the liquor filling spout is a jointed pipe that has a right angle bend that will allow the pipe to fit down through the charging opening when in the charging position. If allowed to drop below or above the center line of the Chicksan joint, the right angle on the filler pipe in the digester is no longer on the center line of the digester and will cause liquor to impinge on the side wall.

STAINLESS STEEL OVERLAY

Figure 12 shows a stainless steel overlay. In some digesters where the loss of metal in local areas has become excessive, the useful life of the vessel has been shortened. The most successful means of extending this life is to overlay with type 310 stainless steel. The method of applying stainless steel overlay is covered in the TAPPI monograph series No. 12 under Repair of Kraft Digesters (*3*).

The following method has been used satisfactorily to determine the area to be overlayed.

When a suspicious spot is found to be thin by an Audigage reading and the corrosion rate in inches per year is enough that by the next inspection period the safety valve setting would have to be reduced, this is the center point for a grid pattern. From this center point horizontal and vertical grids on 1-ft. centers are drawn and Audigage readings are taken at the intersection of the grid lines and recorded. The points of a predetermined thickness are joined by a contour line and the area enclosed by the line is the area to be overlayed.

There has been a total of approximately 900 sq. ft. of overlay applied to 12 digesters in the West Virginia Pulp & Paper Co. within the last three years. The only maintenance to this overlay has been the touching up of the thin spots where the weld beads have been too widely spaced. With the cost of type 310 stainless steel overlay being $17 to $25 per sq. ft., another means of preventing the loss of metal that is less expensive is being tried, that is spray metallizing. Although it has been used successfully in some mills of the industry it has not been in service at West Virginia Pulp & Paper Co. sufficient time to evaluate.

The excessive loss of metal in wood pulping digesters that were made just prior to and following World War II has been falsely blamed on the steel manufacturers, when the paper mills have changed the chemical composition of the cooking liquor and have increased production per vessel during that time.

The advent of the black liquor burning recovery boiler just prior to World War II was the greatest change in the chemical composition of the cooking liquor. One of these changes was that elemental sulphur was substituted for by some other means to maintain sulphidity. This change meant that the polysulphides which acted as corrosion inhibitor when added to the white liquor were reduced. To illustrate this point the following examples are cited:

CORROSION ON CIRCULATING LIQUOR SPRAY NOZZLE AND HANGER

Figure 13 illustrates the corrosion that had taken place in a digester that had been in service for 22 years with an over-all corrosion rate of approximately 0.005 i.p.y. During this time elemental sulphur had been used.

In 1952 the circulation and spraying was removed and a new spray nozzle was designed and put in this digester. The strap hangers extending from the new

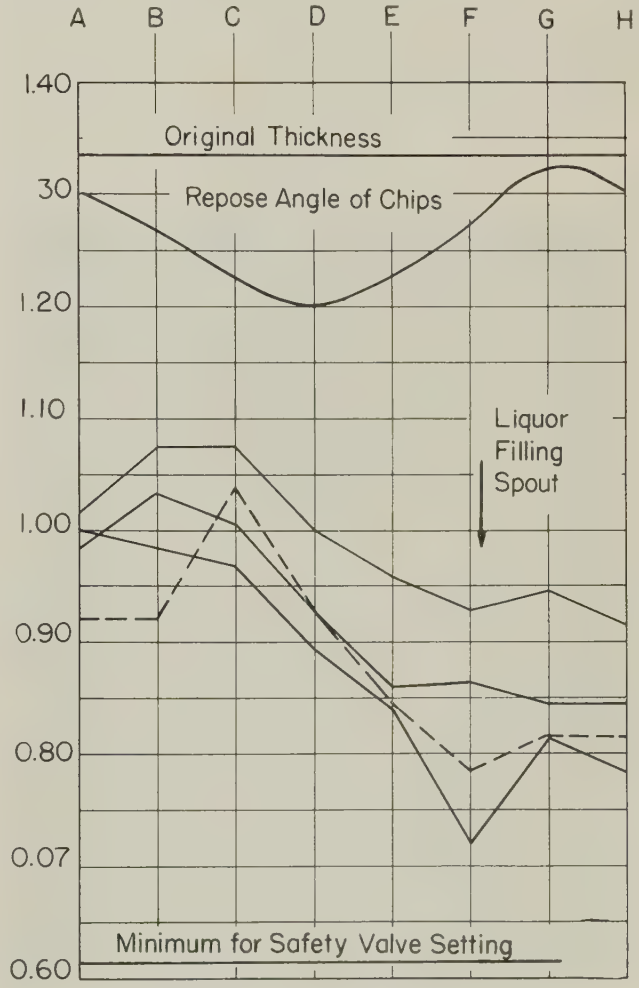

Fig. 11. Thinning due to impingement

pipe containing three new 3-in. tube turns to the head of the digester was made from $^3/_8$-in. thick barstock. At this same time elemental sulphur was substituted for by spent caustic (almost pure sodium sulphide) to maintain the sulphidity. These were the only changes made.

After 8 months of service this digester was again inspected and was found to be badly corroded. The $^3/_8$-in. thick strap hangers were less than $^1/_8$ in. thick and badly pitted. The tube turns were less than $^1/_8$ in. thick. There was a corresponding loss in the other six digesters of the mill.

When the excessive loss of metal was discovered the use of spent caustic was discontinued and the mill returned to the use of elemental sulphur.

The strap hangers were replaced. After 2 years of service these new hangers have not changed in appearance and the loss of metal in the balance of this digester and the other six digesters is within the expected error of the Audigage.

In one of the other mills the over-all corrosion rate or the average loss of metal for the entire side wall of the vessel had been approximately 0.005 i.p.y. before a recovery boiler was put in service. There were five digesters that had been in service ranging from 21 to 27 years. These digesters were covered with a thick carbonate scale. One digester that had been in service for less than a year had no scale.

After the recovery boiler had been in service 2 years using salt cake to maintain sulphidity the newest digester had 215 sq. ft. of stainless steel overlay on the head of the vessel. The other vessels had a higher over-all corrosion rate than previously.

This mill then started using elemental sulphur added to the white liquor. The over-all corrosion rate for the

Fig. 12. Type 310 stainless steel overlay

Fig. 13. Circulating liquor spray nozzle

vessels for the past year is within the expected error of the Audigage on all digesters.

Still another mill had a corrosion rate of approximately 0.060 i.p.y. for the vessel. Since adding elemental sulphur to the white liquor after causticizing, the corrosion rate is now 0.006 to 0.008 i.p.y. for the vessel.

It can be seen from the above that polysulphides do play an important part in helping to reduce corrosion if added to the cooking liquor after it has been causticized. Some mills have experienced accelerated corrosion when the elemental sulphur was added to the causticizing tank, or before. This may be due to the converting of the polysulphides to one or more of the other more corrosive sulphur compounds before it can be absorbed by the chips during the cooking.

SUMMARY

In summary the following can be done to reduce the loss of metal in digesters.

1. The use of deflector to prevent erosion. These deflectors are 2 in. wide bands of steel welded at an angle to the side wall such as shown in Figs. 8 and 10.
2. Redesign the circulating liquor spray nozzle such as shown in Fig. 13. The tube turns converge at a point 15 ft. below. This will help eliminate the washing of the side walls.
3. The use of type 310 stainless steel overlay to prevent further loss of metal in localized areas.
4. The use of elemental sulphur to prevent the over-all corrosion.

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The Development of the Idar Stock Refining Process

E. H. CUMPSTON, JR.

A brief history of the development of a new pulp refining method is presented, beginning with the desire for such a method and tracing the development process through to the final embodiment in a refining machine. The first step was the construction of a turbulence machine which proved worthless for refining but was invaluable for guiding succeeding steps. Succeeding steps were on fiber on fiber, small clearance, impact, and so-called microrefining techniques. This work led to the selection of high pulp consistencies as a prerequisite. Means for the uniform and controllable circulation of consistencies over 20% were considered, and one technique was selected and carried to a machine design. The type of fiber treatment achieved and the operating characteristics of the machine are discussed and some conclusions drawn. The application of this machine to cotton linter pulp is covered briefly and some data presented.

THIS is a brief chronology of the design and testing that led to a new stock refining method. The embodiment of this method is a refiner named the "Idar." The Idar has shown most promise on hard fibers, such as cotton linters, for which some data are presented.

INITIAL INVESTIGATIONS

Initial trials were made, based on wood pulp, and involved the results of numerous investigations. Preliminary studies were made to determine the relative importance of the two types of action that occur during conventional bar-type refining, these actions being: (1) the purely mechanical abrading and bruising that fibers receive when they are caught between passing bars, and (2) the flexing that fibers receive in the turbulence that exists during the rest of the refining process. The large adsorptive property of cellulose, plus the huge excess of water lubricant, was assumed to protect the fiber from appreciable mechanical action during the turbulent part of the normal refining process.

Because of the greater extent of the turbulent action, it was thought at first that this action must be the more important in the overall refining process. A turbulence machine was built using polished surfaces, small adjustable clearances, and speeds up to 40,000 surface f.p.m. The turbulence was terrific, but the refining action negligible. The conclusion was reached that mechanical action and mechanical action alone was the active force at normal power input.

The next question to be answered was the type of mechanical action that was most desirable. At this point, laboratory tests were run to determine if satisfactory fiber treatment could be accomplished by pressing and rubbing fibers together, or if it was necessary to circulate pulp to bring each fiber into contact with some foreign element. Tests indicated that fiber on fiber action could produce physical change, but that this change was limited to a small percentage of the fibers and did not produce good fiber bonding. A foreign element was deemed necessary.

Three general methods of achieving mechanical action on fibers at normal pumpable consistencies were considered. These methods, along with the resulting conclusions, are:

1. Fibers could be forced through a space sufficiently small to insure mechanical action. This is the method in general use and carries with it the major difficulty of controlling small dimensions. Under production conditions, it is difficult to imagine a degree of control that would prevent the mechanical action from ranging between a clean miss and a destructive blow. (A destructive blow was considered as visual damage to a fiber that either shortened it or obviously weakened it.) Individual fiber dimensions and the number of fiber thicknesses caught in this small space at one time are, of course, beyond control. It is also apparent that considerable power is required to force pulp through a narrow space, such as between two bars, and that a clean miss is a power waste.

2. Pulp could be struck with such velocity that a sharp edge on the striking element would be forced through the protecting water film and mechanically treat the fibers. Within limits, the sharper the edge, the lower the velocity could be. To a limited extent, this type of action must also be present in bar-type refining. Laboratory tests showed that even with extremely sharp edges the required velocity drew prohibitive power. Refining by this method alone produced remarkable hand sheet data, but ran the horsepower hours per ton up into the thousands. It appeared almost impossible to produce destructive mechanical action on fibers by this method, and certainly the clean miss was prevalent.

3. Pulp could be mixed with abrasive grit and stirred. The author would like to point out here that this was considered a laboratory method only. This method produces the ultimate in sharp edges and in refining area. The surface area of a handful of grit (say no. 40) is equal to the bar area of a large jordan. Since the grit is traveling along with the pulp there is no opportunity for streamline flow around the sharp edges and the forces required for penetration of the water layer are greatly reduced. Phenomenal handsheet tests were produced at about 1 hp. day per ton. Here the clean miss was rare, and the destructive mechanical action nonexistent. In fact, at 150 magnification there was no visual effect on the fiber, and the Canadian Standard freeness did not change. However, it was evident that the entire surface of the fibers had been made sticky.

The above investigation was pure research, but it did point out that closer control of the refining action would produce higher physical strengths, that destructive mechanical action was desirable only for its effect on sheet formation and density, and that appreciable power savings were possible.

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Fig. 1. Steel tackle on cotton linters, showing cutting debris, some minor fibrilation and much residual linter kinkiness

High consistency refining appeared to be a way of obtaining better control, higher strength development, and reduced power requirements. At high consistency pulp would have sufficient viscosity to hold fibers against the refining element almost regardless of the clearances or speed at which the element ran. Under this condition viscosity (consistency) and speed could be regulated to reduce destructive action greatly and yet, at the same time, clean misses would be rare. This desirable combination led to the selection of high consistency as a prerequisite for the new refining method.

It was now possible to describe the requirements for the new refining machine: (1) It should work at the highest practical consistency where the refining clearances could be large for good control and where there would be a minimum of water lubricant to interfere with mechanical action on the fibers. (2) The pulp consistency and/or the refining element speed should be variable to give broad control of the action. (3) It should have as large mechanical refining surfaces as possible to be efficient. (4) It should have sharp edges on the refining surfaces to break through the adsorbed water surfaces. (5) It should circulate or turn the pulp to present all the fibers to the refining surfaces. (6) Continuous refining, rather than batch, was accepted as a requirement.

From the above requirements, certain characteristics of a new machine could be assumed: (1) Conventional bar-type tackle could not be used because high-consistency pulp would not circulate around the bars. Circulation by turbulence would be impossible. (2) At high consistency the refining clearances or spaces could be comparatively large, the pulp being stiff enough to hold itself against the refining action. (3) The refining surfaces could be intricate because the large refining spaces would obviate grinding in or touching of one surface on another. (4) The pulp would have to be carried through the refiner since normal pressure flow could not be counted upon at high consistency. Restriction of the discharge is impractical, also. Circulation was, and is, one of the major problems encountered in high-consistency refining. Dense fibrous material does not lend itself to positive circulation. (5) The lack of fluid pressure forces (pump pressure) could simplify the machine design. (6) Adjustment of the large refining spaces would not be critical and could be expected to have reduced effect on the refining action. In fact, it seemed very possible that no clearance adjustment would be required, the destructive mechanical action necessary for formation being supplied by another refiner.

Numerical data obtained up to this point are the source of continuing development work and therefore are not presented at this time.

CIRCULATION OF HIGH CONSISTENCY PULP

The positive circulation of high consistency pulp was by far the most stringent demand and was therefore the first to be considered. A few of the steps in arriving at one solution to this problem are: (1) Large refining clearances had already been decided upon. (2) Throttling of the pulp discharge was ruled out as untrustworthy because of the tendency to plug. Large clearances, plus the inability to throttle the outlet eliminated the direct use of centrifugal force as a circulating means because under these conditions there would be only a momentary and uncontrollable holding time. Holding time, or throughput rate, of course controls the amount of work done, especially when the refining clearance has been more or less eliminated as a control means. Even in conventional refining practice, the clearance appears to have much more effect on the type of work than on the amount of work done. (3) The development of a "pump" to force throughput was decided against for two reasons. First, such a "pump" seemed a major undertaking in itself, and second, the absence of normal turbulence or mixing made pressure circulation appear likely to produce severe channeling and very uneven fiber treatment. (4) It was realized that interlocking mechanical surfaces could be given a sinusoidal motion to produce true positive circulation. However, the cost of building and maintaining such a system was considered too high. (5) It was finally decided that transport of high consistency pulp by rolling was worth a try.

The advantages and disadvantages of rolling as a transport method were investigated. The apparent disadvantages were: (1) It was expected that not all pulps could be held tightly enough to be rolled at practical speeds. Laboratory work showed that all

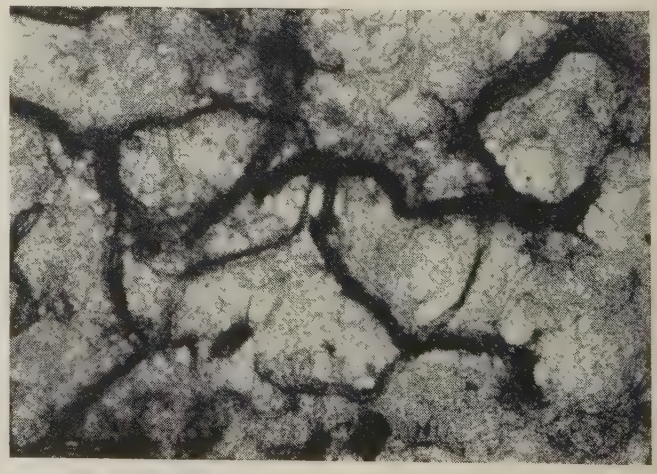

Fig. 2. Cotton linters after 32 passes through a lava-filled jordan, at which point maximum sheet strength was developed. Cutting and debris formation are very evident and yet the remaining fiber is still kinky. Tearing strength was very low

available pulps would roll at slow speeds but that some pulps would not form hard rolls. (2) It was recognized that with this transport system, the holding time would be a function of the size and speed of the refining surfaces. The transport velocity of a pulp roll would be one-half the speed of the driving surface, and the length of the roll path would be determined by the size of the refining surface. Holding time equals length of path divided by transport velocity. Varying size and speed appeared to be a large order. (3) Rolling was not an ideal method for obtaining positive circulation. There is a limit to the frequency and depth to which a roll can be punctured and have it remain a roll. Fibers in the center of the roll will be underexposed to the mechanical refining action if the roll is too large. (4) The consistency of the pulp to be rolled would have to be maintained within certain limits. At too low a consistency the rolls would disintegrate under centrifugal force. At too high a consistency the pulp could not be formed into rolls, but would be ground up by the rolling surfaces.

The apparent advantages were: (1) Laboratory work indicated that pulp consistencies well over 20% could be handled. (2) Easily produced surfaces appeared capable of forming and maintaining rolls and at the same time these serrated surfaces would puncture the rolls to provide the mechanical refining action. Large, sharp refining surfaces seemed possible. (3) The required holding time was expected to be very short, the rate of fiber development being high. The rolls were expected to reach 150,000 r.p.m. or more. (4) It was discovered that the formation and circulation of rolls provided a marked dewatering action. There was hope that this dewatering tendency could be used to do most of the work in obtaining the high consistencies desired for refining. If this proved the case, then the problem of dewatering pulp ahead of this machine would be lessened.

It now appeared as if the basic principle of rolling high consistency pulp between serrated surfaces would fulfill most of the requirements that had been set up. Only requirement no. 2 seemed troublesome (allowable variation of speed and consistency). Speed would be limited on the high side by roll endurance and on both sides by its direct effect on holding time. The inherent dewatering action of rolling would probably dominate consistency control. Nevertheless, rolling transport appeared to be practical so a machine was designed and built.

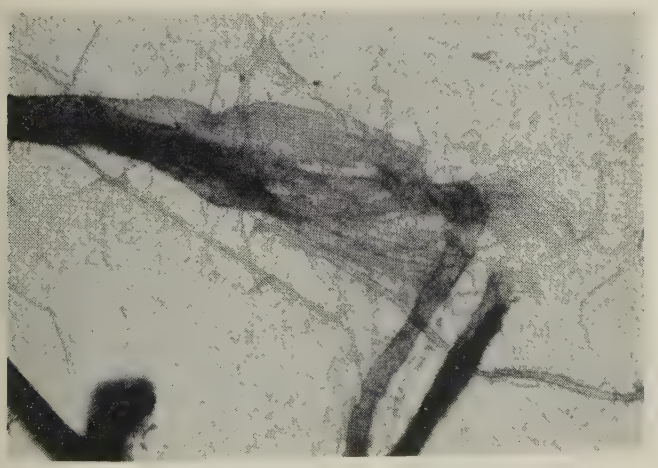

Fig. 3. Cotton linter fiber after one pass, showing coarse splitting without the creation of excessive debris

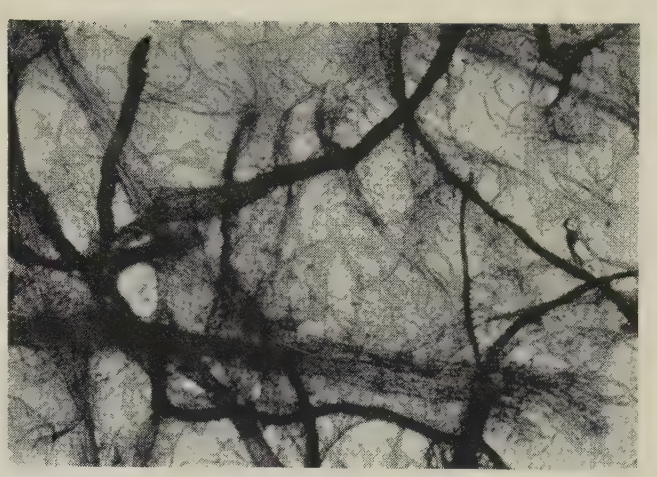

Fig. 4. Full Idar treatment of cotton linters showing coarse fibrilation, lack of cutting, removal of kinks and relatively little debris. The shrink hole is evidence of attached fibrilation

MACHINE DESIGN

The machine was called the Idar from "integral dewatering and refining." The design of a commercial Idar was aided by first building and testing several small machines.

The refining surfaces came first. The production of the serrated rolling and refining surfaces is a simple matter on a flat surface and quite complicated on any other geometric surface. The Idar, therefore, became a disk machine with one rotating and one stationary disk.

The design of the serrated surfaces was straightforward. The surfaces must grab and hold pulp rolls which would be as small as possible to allow working of the inner fibers. This called for closely spaced points. These points must puncture the rolls to refine the pulp. This called for sharp points, as opposed to ridges. If the points were too close together and therefore too small, they would not dig deep enough into the rolls. The spaces between points must be deep enough to let the points dig into the rolls and yet these spaces must not be so deep that they will hold pulp lodgements and eventually pack full. Experimentation produced a surface covered with 90° pyramids, the number of pyramids per linear inch ranging from five to ten depending on the type and condition of the pulp being worked.

The assumption was made that sufficient centrifugal force would be generated to gradually work the pulp rolls out to the periphery of the disks for discharge, the rolls following a spiral path starting at a centrally located inlet. This premise agreed with the earlier one that holding time would be a direct function of refining surface size and speed.

Next, the pulp inlet was located and adjusted. It should be remembered that the disk surface and disk spacing were arranged to hold fibers and that no practical inlet pressure could force pulp between the disks. It must be rolled in. To promote this rolling the inlet was placed off center in the stationary disk. The rotating disk thus swept across the entire inlet area.

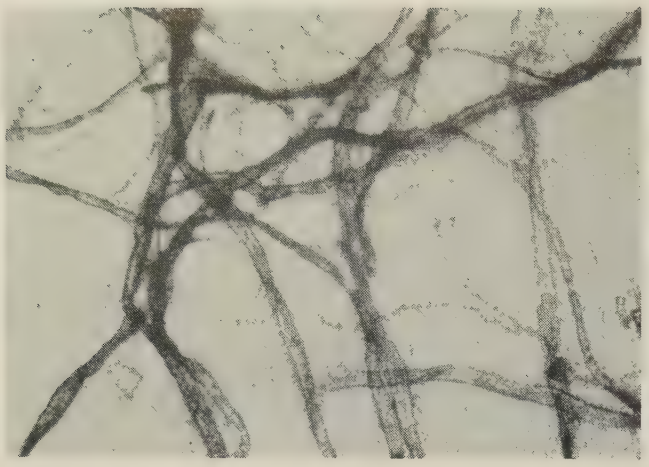

Fig. 5. Excessive micro-refining of cotton linters at 25% consistency, showing the indistinct fiber outline caused by this abrasive grit type of treatment. The lack of cutting, coarse fibrilation, and debris is evident; but many kinks and twists remain. Photomicrographs by K. P. Kries of the General Electric Company, Pittsfield, Massachusetts

Dewatering was known to accompany the formation of rolls and the speed at which these simultaneous actions were performed was also known to be somewhat critical. Too high a roll formation speed would not give the excess water time to leave, and the potential roll would burst with the escaping water. Too low a speed would drive off so much water that the pulp would act almost as a solid and would be ground in between the disks rather than rolled in. This grinding action ruined the fibers and greatly reduced the throughput.

Adjustment of the roll formation speed was accomplished by moving the position of the inlet relative to the center of the rotating disk. The further the inlet was from the center of the rotating disk, the greater the speed at which the rotating disk swept across the inlet area. Since the inlet was part of the stationary disk, it was necessary to give the entire stationary disk an adjustable motion parallel to its working surface. This adjustment was made by mounting the stationary disk on an eccentric axis and moving it about this axis to position the inlet. This same adjustment could have been accomplished with a variable speed drive for the rotating disk, but this was too expensive for consideration.

The design of the rest of the refiner was a relatively simple job. The thrust on the disks was very much less than for a conventional disk refiner because there could be no pump pressure between them. An inlet pressure of 30 p.s.i. on a conventional 36-in.-diam. disk machine will produce a thrust of considerably more than 30,000 lb.: on the Idar this inlet pressure is effective only across the 4-in.-diam. inlet and produces about 380 lb. thrust. The Idar has a thrust bearing, but it is not heavily loaded. The disk clearance adjustment mechanism was also lightly loaded and simple in construction. The Idar must have a free discharge (see above) which eliminates the need for shaft seals, in fact, the cover over the disks is set in place without bolts.

OPERATING CHARACTERISTICS

The ability of the Idar refiner to dewater is much greater than was anticipated. The refining surfaces are built to catch and hold fibers so that fiber rolls can be transported. There is nothing on these surfaces that will prevent the free escape of water between the pulp rolls. A dewatering technique of unforeseen capacity was hereby created, namely, that the inlet feeding pressure tended to squeeze water out of the pulp. This water is free to run out between the refining surfaces at a greater rate than fibers are formed into rolls and carried away from the inlet. The effect is similar to placing pulp on a coarse wire screen and pressing the pulp against the screen; the fibers will be held and dewatered while the water flows through the screen.

There is also the aforementioned dewatering action that occurs during the formation and transport of the pulp rolls. The pulp is squeezed as it is grabbed by the rotating disk and dragged across the stationary disk to form a roll, thus ejecting some water. Once the roll is formed and begins to be transported, it rotates at a very high speed about its own axis and is also rotated at a much slower speed (one-half the rotating disk revolutions per minute) about the rotating disk axis. Both of these rotations create centrifugal force that removes still more water. On the outside of a pulp roll the centrifugal force on water may reach 15,000 times its own weight. Under these conditions a drop of water would have a separating force of 1 kg.

This combination of dewatering actions makes it possible to supply the Idar with pulp at normal pumpable consistencies and still refine at densities that are estimated to be as high as 50%. The actual pulp density during refining cannot be measured because the high density pulp rolls are discharged along with the removed water and mixing of the two cannot be prevented. Inlet pressures between 15 and 30 p.s.i. and feeding consistencies of 4 to 6% have been successful.

The action of the Idar on fibers is unique. The very nature of rolling transport precludes small disk clearance. In operation the Idar disks are as much as $^1/_8$ in. apart and are not run closer than $^1/_{32}$ in. At normal pulp refining consistencies this working clearance could do no fiber development. Direct mechanical cutting of a fiber is not possible, and fiber shortening is limited to fraying through or breaking under stress. Rolling transport also precludes scrubbing or grinding of the fibers across the refining surface, since the roll surface moves with the refining surface. The refining action is therefore limited to the puncturing of the rolls by the pyramids on the disk surfaces with the resistance to

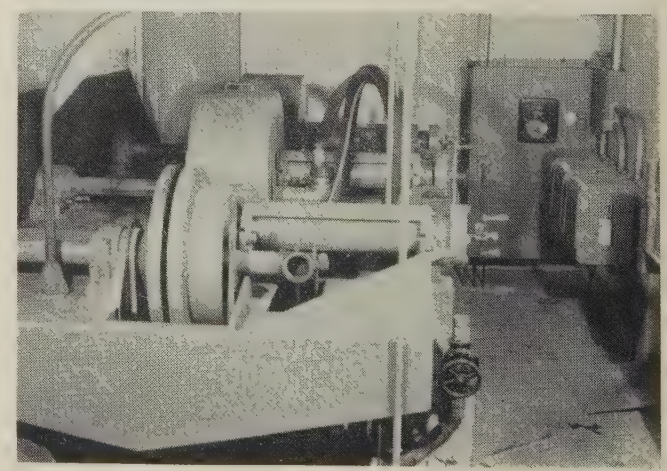

Fig. 6. The Idar installation at Byron Weston Co. Note the hoses by which pulp is supplied to the moveable inlets

this puncturing supplied solely by the high density and not by the opposite disk surface.

Fundamentally, the Idar is a rapid and efficient fibrillating machine. In comparison with conventional bar-type refining, the Idar will produce an equivalent degree of fibrillation with a fraction of the cutting for a fraction of the power and with slightly less so-called "hydration" and gel. The slight reduction in "hydration" or stickiness is explained by the rapidity with which coarse fibrillation is generated by the Idar, there being many fewer contacts between fiber and refining surface required for any given degree of fibrillation. Also, the Idar pulp will be freer, there being less debris and gel.

The Idar refiner is not easily applied to wood pulp for several reasons, perhaps the most important of which is the inability of many wood pulps to withstand rolling transport at practical speeds. If a pulp roll disintegrates the refining action stops. The Idar develops wood pulp so rapidly that control is difficult and, in many cases, the desired amount of treatment will be surpassed with a single light pass. An interesting point was discovered in applying the Idar to wood pulp, namely, that even though shortening is minimized, coarse fibrillation of wood pulp will definitely fit under the destructive blow discussed above. While the Idar on wood pulp will equal or in some cases slightly improve on strengths developed in more conventional equipment, it cannot compare with the results obtained, using impact or abrasive grit. Apparently, the damage done to wood pulp by this coarse fibrillation is slightly more than compensated for by the absence of cutting which occurs in bar-type refining.

It is believed that the most important use of the Idar will be on fibers difficult to process, such as cotton linters. Here, where the outer wall of the fiber is tough and the fiber is kinky, the Idar would seem to present the proper treatment. These fibers must be made to lie down and they must be made sticky. In general, there would seem to be only two mechanical refining methods capable of making such fibers lie down, namely, cutting them into short lengths or splitting them.

It appears impossible to split cotton linters at normal consistencies without also cutting them. Under these

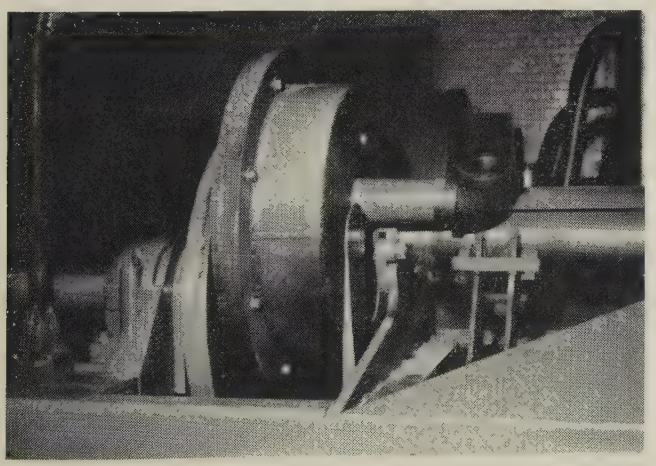

Fig. 7. A view of the Idar stationary disk raised well above the rotating disk for rapid roll formation and dewatering on a free pulp. The inlet pulp hose has been disconnected

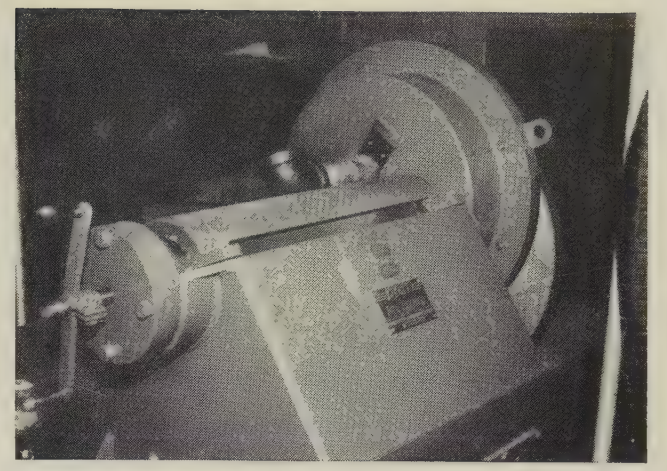

Fig. 8. Another Idar view showing the clearance adjusting crank and the raised stationary disk

conditions, by the time sufficient density has been reached to produce paper, the possibility of good strength development has been lost due to shortening.

The Idar will produce good density (0.6 TAPPI Standard handsheet) and still retain good fiber length. In the process of opening and fibrillating linters, the Idar will produce stickiness, but for ultimate development, it is probably necessary to create more stickiness or "hydration" on the opened fibers by some more gentle means.

Incidentally, cotton linters will not respond to the abrasive refining technique mentioned above because this treatment cannot build sufficient density for good fiber bonding and may not be severe enough to open the outer wall. The abrasive method has never been tried on Idared linters, but it should be the best type of treatment to follow the Idar.

Turbulence loss in the Idar is almost zero, and the clean miss is difficult to imagine which explains the low power required by this machine. The Idar disks are not capable of creating much turbulence even if they ran almost touching, and since they run some distance apart and their speed is relatively low (36 in. diam. at 400 r.p.m., or 3760 f.p.m. maximum velocity), the turbulence level is very low. In fact, if the machine is set so that dewatering does not occur, it will coast for minutes with pulp flowing through it. Another indication of the low turbulence level is the almost complete absence of noise or vibration during full power operation. Because the Idar type of fiber development is quite different from other refining methods, it is difficult to give any exact ratio of power requirements, however, several tests on kraft pulp showed that the Idar would develop equivalent strength for about one-third the power required on a mill beater.

On cotton linter pulp there have been no equivalent strength development samples available, but here again, a two-thirds power saving is a conservative estimate.

The throughput capacity of the refiner has already been discussed and was shown to be a direct function of the working surface speed and area. A pulp roll has no choice but to move outward along a spiral path at one-half the revolutions of the rotating disk. The speed of the rotating disk also determines the steepness of the spiral by controlling the centrifugal force which continually works the pulp roll outward. Surface speed and pulp roll diameter are selected for optimum de-

Table I. Handsheet Data of Idar Versus Conventional Equipment

	Refiner A	*Refiner B*	*Refiner C*	*Refiner D*	*Beater E*	*Idar L*	*Idar 16A*	*Idar 16B*
Schopper Riegler, ml.	...	670	...	615	600	395	...	260
Canadian Standard freeness, ml.	270	335	Minus	...	...	120	110	50
TAPPI burst factor	16.4	13.7	19.3	7.6	9.2	20.4	24.8	26.5
MIT fold	12	6	...	3	...	13	...	36
TAPPI tear factor	177	100	60	67	...	109	167	138
TAPPI density	...	0.472	0.640	0.517	0.550	0.613	0.603	0.643
TAPPI breaking length	...	2523	4030	963	...	3174	4220	4520
Power, hp.-hr./ton	1200	1800	1512	...	400	600	1200	1600

watering, roll formation, and roll transport conditions. Since these conditions are paramount to successful operation, throughput becomes a dependent variable. It can be seen that inlet pressure has only a minor effect on throughput; this minor effect is due solely to the dewatering that inlet pressure can accomplish. Even working surface areas become a dependent variable with the Idar embodiment of rolling transport. The principle of adjusting the position of the inlet by moving the entire stationary disk precludes the use of more than one inlet. The surface speed of the rotating disk past the pulp inlet is adjusted for proper operation so that the use of larger disks on a single inlet will not lead to the formation of any more pulp rolls.

By its basic nature, the Idar is a low capacity machine. The throughput rate for cotton linters is presently ranging from 300 to 1000 lb. per hr. Where heavy fiber development is required, the Idar has a production rate comparable with a conventional refiner having roughly three times the coupled horsepower. The present recommendation is 150 hp. for an Idar which means that the comparable refiner is a big one.

Adjustment of the Idar for the desired fiber treatment is done by the crank which raises and lowers the stationary disk. This positions the inlet for the proper speed of roll formation and thus determines the amount of dewatering and the throughput rate. The type and condition of the incoming pulp will greatly affect this setting. A long, free pulp will dewater and roll easily and can therefore be handled at a higher rate than a short, slow pulp.

Table II. Handsheet Data of Idar Versus Other Experimental Machines

	Refiner A	*Refiner B*	*Refiner C*	*Idar L*	*Idar 1123*	*Idar 16B*
Schopper Riegler, ml.	...	...	450	395	310	260
Canadian Standard freeness, ml.	...	...	...	120	85	50
TAPPI burst factor	11.4	12.6	13.1	20.4	23.4	26.5
MIT fold	6	9	...	13	28	36
TAPPI tear factor	51	97	104	109	123	138
TAPPI density	0.649	0.570	0.621	0.613	0.595	0.643
TAPPI breaking length	2190	1300	1800	3174	4010	4520
Power, hp.-hr./ton	...	...	...	600	1000	1600

Table III. Idar Linters Versus 100% Rag Handsheet Tests

	Average of three rag mills, rag stock before the jordan	*Handsheet range, Idar processed linters*	
Schopper Riegler, ml.	655	..	260
Canadian Standard freeness, ml.	375	110	50
TAPPI burst factor	21.2	24.8	26.5
MIT fold	28	..	36
TAPPI tear factor	216	167	138
TAPPI density	0.544	0.603	0.643
TAPPI breaking length	..	4220	4520
Power, hp.-hr./ton	..	1200	1600

The disk clearance adjustment has a surprisingly small effect on power and throughput. This adjustment is equipped with a stop which is set for minimum disk clearance when the working surfaces are installed, thus preventing inadvertent touching of the disks. The pulp supply can be shut off at any time without damage to the disks.

It is felt that the proper post-Idar treatment will lead to the ultimate strength development of fibers difficult to process. This possibility is under active investigation. In any event, it is always desirable to follow the Idar with a machine which produces a fairly high turbulence level to insure complete disintegration of the pulp rolls. A machine jordan under light power will handle this clearing operation easily. There is evidence that heavy power on a jordan will dislodge sufficient coarse fibrillation to partially undo some of the benefits of the Idar treatment.

DATA ON COTTON LINTER STRENGTH DEVELOPMENT

The author wishes to acknowledge the cooperation of the special technical committee of the Writing Paper Manufacturers' Association in supplying the following data from experimental work which they conducted.

Table I lists handsheet data from test runs on various types of refiners in commercial use today. In all cases the handsheets were made of unsized linters. In each case the data for the commercial equipment represent the best of several trials. The Idar trials were selected because they represent high- and low-power input trials.

This comparison based on handsheet tests indicates

Table IV. Trial Runs of Paper Made of 100% Linters—Processed by Idar and Jordans

	1	*2*	*3*	*4*	*5*	*6*
Weight, lb.	21.0	21.1	20.6	19.0	18.9	20.9
Bursting strength, p.s.i.	36	42	35	35	33	34
MIT fold	104	367	131	149	420	194
Elmen. tear (M), g./sheet	76	64	70	68	55	69
Idar power, hp.-hr./ton	1200	466	623	422	618	954

that the Idar is capable of producing better developed fiber than the other pieces of equipment which were used in the experiment.

Table II contains handsheet data on linters put through experimental equipment as compared with Idar experimental runs on three-power input levels. Unfortunately, comparable input data are not available for the three experimental machines and it is perhaps unfair to make a comparison on a basis of power requirements.

The significant fact about the Idar runs appears to be that it achieves a high level of handsheet test values, especially tear, at all power levels. This is rather borne out by the fact that the Idar sample—1-6B shows a number average length of 2.2 mm. which is almost as high as that of unprocessed linters of this grade which is about 2.5 mm. These tests indicate that the Idar tends to develop the fiber without the usual reduction of length experienced in other equipment. This feature is always of interest to the papermaker.

Table III gives encouragement to further Idar experimentation by indicating that the processed linter handsheet values seem to be safely within the range of beaten rag except for tear. For this latter property, however, the Idar results are the closest to rag of any of the experiments made.

Table IV consists of physical test data on air-dried paper made of linters processed by the Idar machine and regular machine jordans. Unfortunately, the experimental Idar machine is limited in capacity and these data are from paper machine runs of 30 min. duration which did not allow time for manipulating machine variables which have altered some of the sheet characteristics.

In general, visual characteristics and writeability of these trials are adequate for the requirements of good writing paper or letterheads. The physical tests leave something to be desired, but it is expected that larger mill trials will permit further experimentation in this field.

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Noise Problems in Pulp and Paper Mills

M. N. DAVIS and R. H. CASTON

Although there are many reasons to be concerned about high sound levels in pulp and paper mills the possibility of a noise induced hearing loss is of primary importance. Noise measurements and the relation of noise levels to hearing loss are discussed. At the moment the most reasonable criterion for a dangerous noise environment is that of H. C. Hardy who says" ...Research data taken from a survey of industrial noise serve to establish two octave band curves which tentatively appear to bracket the region for damage risk for daily exposure over many years to a steady state noise environment. When the noise exceeds 100 sones in any octave band, long exposure definitely appears to be damaging. When the noise does not exceed 50 sones in any octave band there appears to be very little danger of hearing damage even after many years of working day exposure...." Eleven samples of octave band data from pulp and paper mill noise sources are compared to this criterion. General remedies for noise problems are mentioned and the Abbott and Krause gap silencer for suction roll noise is described in detail. Finally, the Kimberly-Clark experience in the use of this silencer is reviewed.

It was only a few years ago that noise in industry was considered a nuisance which had to be endured and could be ignored. However, as industry consumed more energy and converted a constant or even increasing percentage of this energy into noise, the number and magnitude of the noise sources grew apace. At the same time the harmful effects of noise on man were being learned. As a result of these two factors, noise is no longer ignored, and a large body of lawyers, doctors, and technical men are devoting a great deal of time to noise abatement.

Although a small library of words has been written about the harmful effects of noise, a few of the high points to emphasize the importance of noise problems should be mentioned briefly: Noise causes fatigue, making workers more prone to accidents and their jobs more irksome. Noisy areas are unpleasant and are generally avoided by mill personnel, even by some who would normally have reason to visit the areas. Noise inhibits audio observation. In the low level sound of a smooth running engine one can tell immediately when something is wrong by the change in the sound. By contrast, in the loud discord of a noisy machine room it is usually impossible to tell by listening when a mechanical failure is occurring until the costly repair stage is reached. Noise interferes with communication. For this reason much of the routine business in a paper mill is carried on by hand signals. However, it is the unexpected and dangerous situation which needs the warning shout. When this warning shout cannot be heard because of noise, personal injury, or property damage may result. In other cases extra-routine or experimental procedures may be carried out on a machine. The success of these experiments usually depends on some sort of communication between the personnel carrying out the experiment and when communications fail because of noise, the experiment fails. Finally, it is known that noise can cause deafness.

MEASUREMENT

Before a noise problem can be attacked it must be possible to measure and evaluate the noise. Nature has equipped us with two good noise detectors, but unfortunately they are connected to a brain which is not calibrated in any mass, length, or time units known to us and which is capable of changing its calibration without notice. While many aspects of sound must be re-

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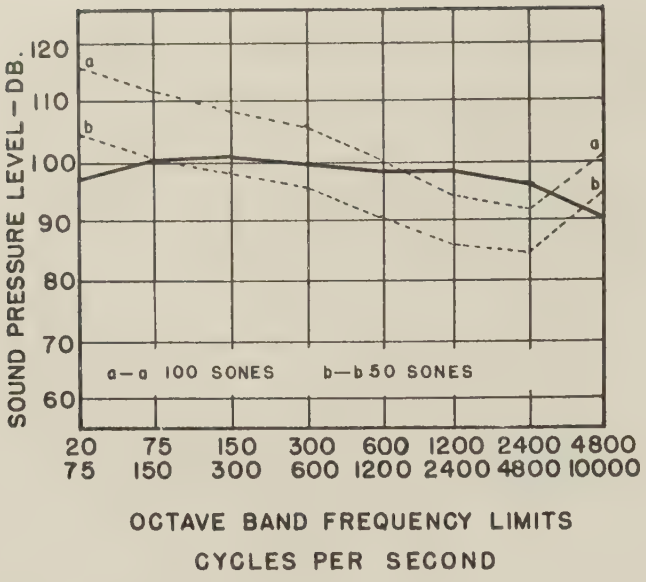

Fig. 1. Chipper noise

lated to how the sound is heard by an individual brain, engineering practice requires the use of refined instruments for studying noise.

The air-borne pressure variations which make up a sound are characterized by the magnitude of the pressure variations and by the frequency of their recurrence. In measuring a sound we are interested in sound pressures which the ear can detect. The root mean square amplitude of these pressures vary from 2.9×10^{-9} to 2.9×10^{-2} p.s.i. The intensity of the sound, or the measure of energy in the sound wave, varies as the square of this pressure and covers a range of about 10^{14} to 1. To avoid unwieldy arithmetic and to save paper when we write about noise and sound, we speak of sound pressure levels in decibels.

The sound pressure level in decibels (db) is defined as:

$$\text{Decibels} = 20 \log \frac{\text{Sound pressure}}{\text{Base pressure}}$$

In most cases the base pressure is 2.9×10^{-9} p.s.i. Thus sound levels vary from zero to $20 \log 10^7 = 140$ db.

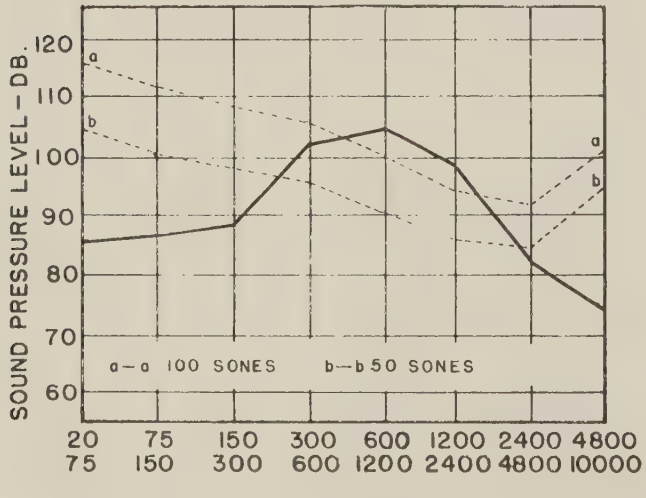

Fig. 2. Groundwood motor noise

In practical industrial noise work there is rarely interest in any levels below 40 db.

In addition to this range of intensities, we are interested in a range of frequencies which are important to the ear, that is, from about 30 cycles per sec. to about 15,000 cycles per sec. It is common practice these days to include a system of frequency analysis in the noise measurement. As far as the technical aspects of noise are concerned the frequency range is divided into octave bands. The frequency limits of these bands are normally 20–75, 75–150, 150–300, 300–600, 600–1200, 1200–2400, 2400–4800, 4800–10,000 cycles per sec. Engineers are sometimes interested in a more detailed frequency analysis in order to trace a noise or vibration to its source. If this is necessary a frequency analyzer with a higher resolving power is recommended.

To measure sound waves a microphone to translate the pressure waves into electrical impulses, a special amplifier to increase these electrical pulses, and a meter on which to read the decibel level are used. The re-

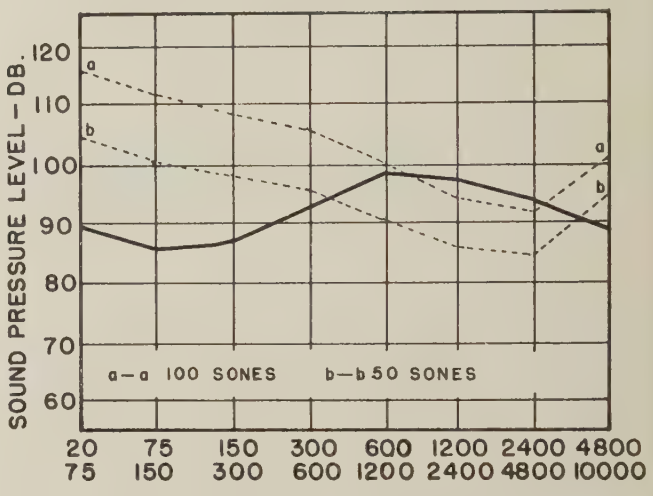

Fig. 3. Refiner noise

quirements for these noise measuring components have been rigidly established by the American Standards Association (*1*) and most of the commercial equipment available today meets these standards. It is well known (*2*) that the ear does not hear all frequencies of sound alike. If we wish to measure the intensity of a sound we must weigh the frequency components of the sound according to the sensitivity of the human ear for the various frequencies. Sound level meters usually employ three weighting schemes to meet this requirement. The weighted level is called the sound level and is distinguished from the sound pressure level defined earlier. When the sound levels are above 85 db. the sensitivity of the ear does not vary appreciably with frequency and the sound level and sound pressure level are then identical.

After measuring a sound level one other difficulty is found. From the time we are born we live in a linear world. If we say that one room is 100 ft. long it is, we know, twice as long as a room which is 50 ft. long. If we say that something weighs 2 lb. we realize that it weighs half as much as something which weighs 4 lb. However, if we speak of Denver being 3 db. farther than Chicago or of one noise as 4 db. less than another

noise we soon find that people are more interested in making paper than in talking or thinking about noise. To remedy this situation psychologists have tested a large number of people to devise linear scales of loudness. The unit of one of their scales is the sone, and in general, but not guaranteed for a particular case, judgment of loudness of a sound will be directly related to the number of sones in the sound. In practical work on noise a sone is little used. However, in speaking to management or to operators, a unit of noise which is linearly related to hearing is more readily understood than the decibel. If we wish to determine the per cent of loudness reduction in any given situation the decibel levels must be converted to sones to make the calculation. To make the conversion from decibels to sones the tables found in the "Handbook of Noise Measurement" which is published by the General Radio Co. are recommended. This booklet is also a storehouse

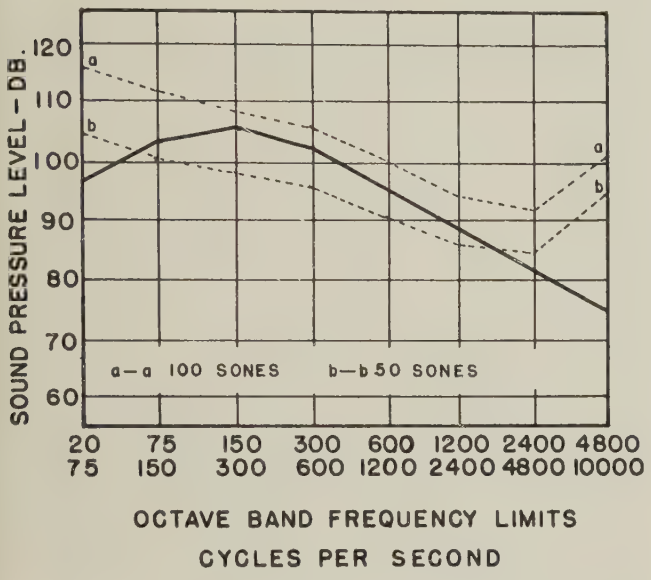

Fig. 4. Drum barker spectrum

of other useful information for anyone who is dealing in the problem of noise.

HEARING LOSS CRITERIA

After this brief summary of the points involved in the measuring and reporting of noise levels, the authors would like to attempt a more definite answer to the question: "When do we have a noise problem?" When communications break down because of noise, everyone is aware of the fact and subjectively judges the seriousness of the resulting problem. When people become fatigued, or work in noisy areas that are unpleasant, they are aware of the problem and they are able to judge its seriousness without noise measurements.

Most of the above effects are capable of definition in terms of sound levels. It then becomes a problem in industrial relations to decide the value of a decibel of correction and an engineering problem to decide how much a decibel of correction will cost.

Hearing loss caused by noise is a more serious problem and unlike the other effects, hearing losses remain after the noise is removed. If we are to believe the experts a noise induced hearing loss usually starts at about 4000 cycles. After a severe loss at this and higher

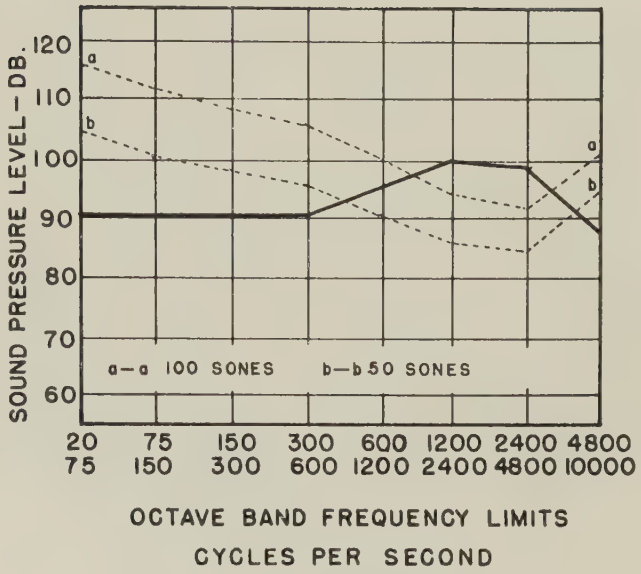

Fig. 5. Slasher saw spectrum

frequencies the hearing loss begins to encroach on the lower frequencies. Since most of our daily activities are carried out with sounds of frequencies less than 4000 cycles, we are not usually aware that anything is wrong until this later stage is reached.

Because we are not aware of the start of a hearing loss, and because a permanent hearing loss is a serious matter which may have economic consequences it is essential that we, who are concerned about the welfare of our employees, know our noise levels and have some criterion of hearing damage.

Experts who are trying to establish damage risk criteria have been hampered by a scarcity of data on noise and hearing; by a variety of estimates of the quantitative effect of age on hearing, and by the complications resulting from the fact that the deafening effect depends on the frequency as well as on the intensity of the noise.

In recent months a subcommittee of the American Standards Association in cooperation with the Acoustical Society of America has investigated the relation of noise to hearing loss. The committee started with

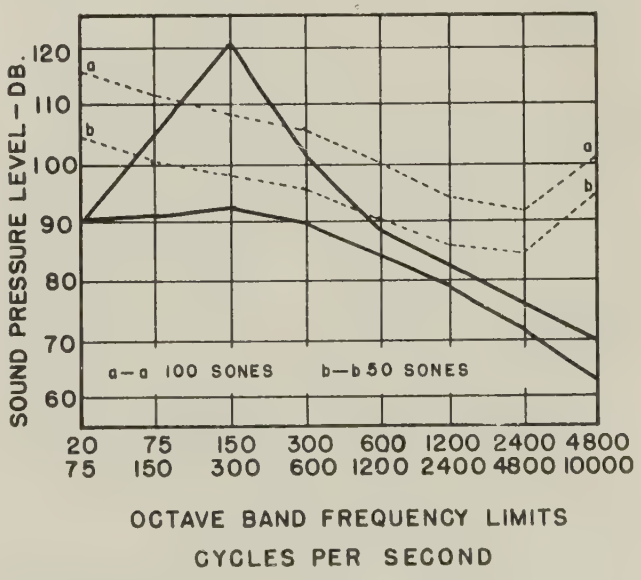

Fig. 6. Silencing of vacuum pump discharge noise

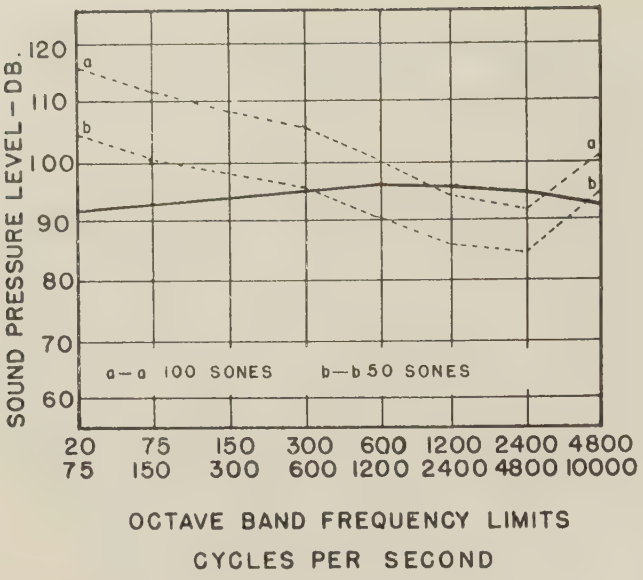

Fig. 7. High pressure air jet noise

tens of thousands of measurements of hearing loss. From these tens of thousands of audiograms they could select only 200 which satisfied their requirements of a known exposure to a known noise with no history of other exposures or damages from disease. From their deliberate treatment of these data they found a series of curves from which an average hearing loss may be calculated for a given exposure. The term exposure includes both the number of years that an individual has spent in a noise area and the level of the noise in the area. The American Standards Association has published the findings of this committee in a report entitled "The Relation of Hearing Loss to Noise Exposure"—a report by subcommittee Z-24X-2.

Of a more practical nature is the estimate of H. C. Hardy (*3*) of the Illinois Institute of Technology. Mr. Hardy makes this statement: "Research data taken from a survey of industrial noise serve to establish two octave band curves which tentatively appear to bracket the region for damage risk for daily exposure over many years to a steady state noise environment. When the noise exceeds 100 sones in any octave band, long exposure definitely appears to be damaging. When the noise does not exceed 50 sones in any octave band there appears to be very little danger of hearing damage even after many years of working day exposure." Other noise exposure criteria have also been proposed (*4*).

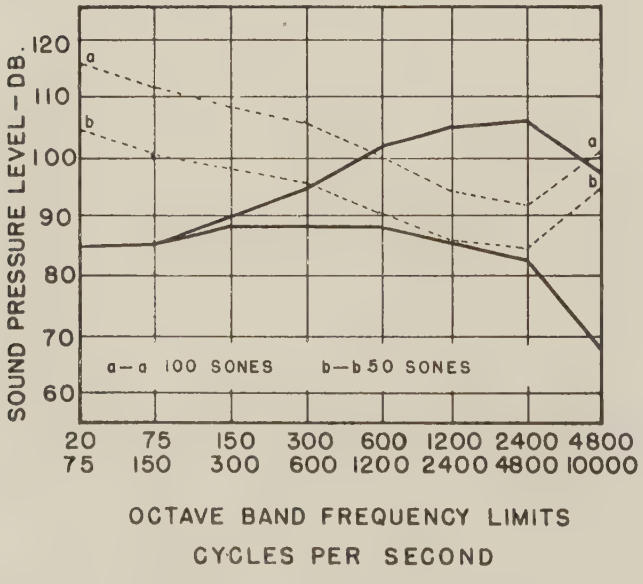

Fig. 8. Noise reduction obtained by enclosing a hammermill

We must always remember that these criteria are guide posts to tell us when we should begin to look for a noise problem. None of them are on a firm enough experimental or theoretical base to be considered as a standard for determining damage risk.

PAPER PULP MILL NOISE SOURCES

Paper mill noise sources which the authors have measured are illustrated in a series of graphs. It will be noted that the Hardy 100 sone level and the Hardy 50 sone level is plotted on the graphs.

Figure 1 is a plot of the noise levels found near a hand-fed chipper. It is to be noted that the chipper feed area noise exceeds the Hardy 100 sone criteria in two octave bands. The noise for an employee in this area can be greatly reduced by the use of a set of ear plugs. Meanwhile, we are in the process of designing a wood room which is hoped will eliminate a great deal of this noise exposure by relocation of the operator and by the addition of sound absorbers in the log chutes.

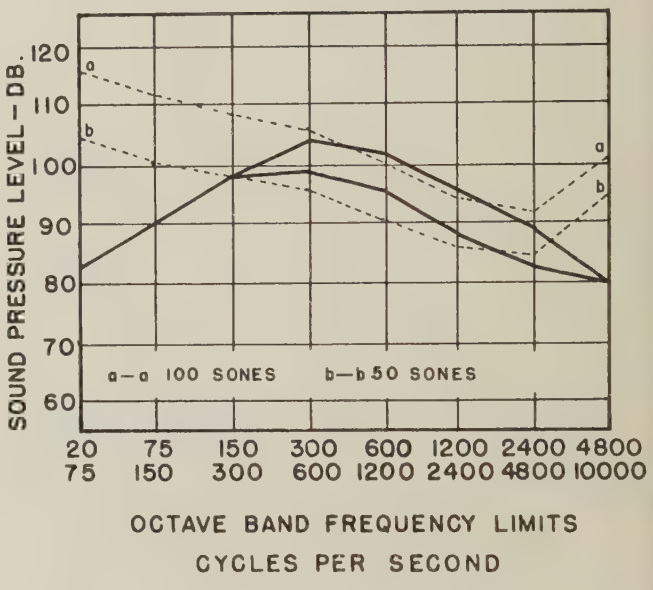

Fig. 9. Noise reduction by partial enclosure

Figure 2 shows the spectrum of noise from a series of groundwood motors. In our case these motors are in an isolated area and do not constitute a noise problem. If they operated in an occupied area the noise could be reduced by means of a soundproof enclosure.

In Figure 3 is a typical sound spectrum of the noise generated by refiners (*5*). In general, these devices are isolated enough to cause us no trouble. If it would be found that this noise is troublesome, a soundproof housing around the refiners would be recommended.

In Fig. 4 is the spectrum of the noise generated by drum barkers. In this case most of the noise is at the lower frequencies. Ear plugs, automatic operation, and some sort of shock mounting are being considered to reduce this noise. Figure 5 shows the general spectrum of the noise generated by slasher saws. These

are about average values while the saws are running. Since these saws are cutting only about half the time these levels are certainly of less significance than a noise which is continuous. However, it is not known how much to reduce the level to compare a continuous and discontinuous noise. Saw operators are encouraged to wear ear plugs or ear muffs.

In the upper curve of Fig. 6 a typical spectrum from a vacuum pump has been indicated. In this case the frequency is quite low but the intensity or sound level is quite high. Commercially available silencers can reduce this noise to negligible proportions as is indicated by the lower curve on the slide. The loudness reduction is 85%.

Figure 7 gives an indication of what may happen in a machine room when high pressure air is used for spot cooling of machine stacks. The hiss of escaping air generates a very high frequency noise. When this is added to the general noise level of the operation there results a rather flat noise spectrum. By going to lower pressure air with larger openings it has been possible to reduce the high frequency portion of this spectrum so that the noise is not objectionable.

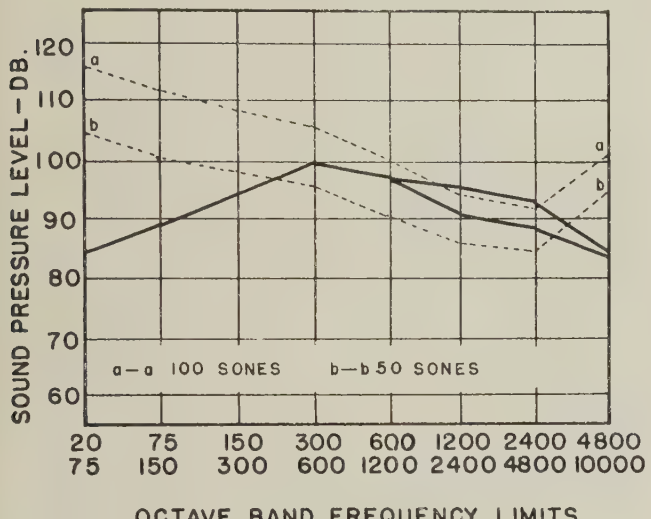

Fig. 10. Noise reduction by cam redesign

The upper curve of Fig. 8 is a typical spectrum of the noise generated by a hammermill. A noise of this type has been successfully reduced by isolating the hammermill operation. Invariably this has meant that the soundproof enclosure house both the hammermill and the parent feed roll. Otherwise the noise conducted out through paper is objectionable. The lower curve is the noise level after enclosing the hammermill. The loudness reduction is 75%.

Figure 9 is a typical spectrum from a converting operation. By means of a partial soundproof enclosure it was possible to reduce this noise to the lower curve. The loudness reduction is 30%.

In Fig. 10 another converting operation is shown in which the redesign of a high-speed cam reduced the noise from the upper to the lower curve. The loudness reduction is 17%. This noise will be further reduced by the addition of round absorbing baffles.

In the foregoing there are examples of the only two

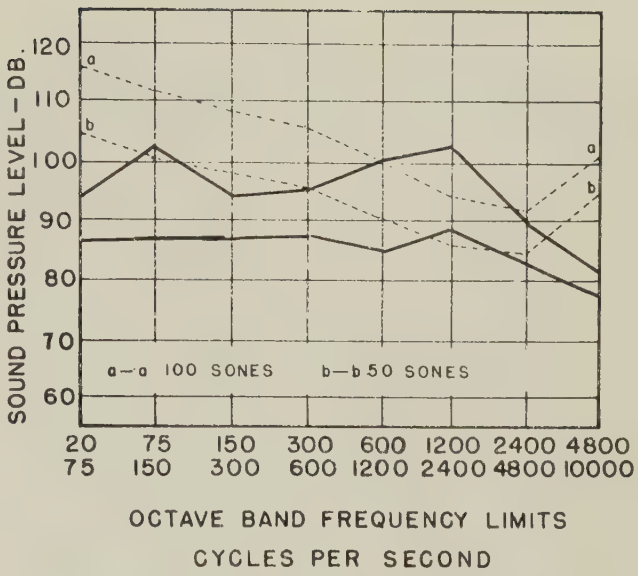

Fig. 11. Tissue mill noise reduction

methods known for the solution of a noise problem. The noise must either be designed out of a machine at the source or something must be done to absorb or block the noise between the source and the listener. Outside of these general principles each problem is a special case.

SUCTION ROLL NOISE

The most important noise to be found in many paper mills is undoubtedly the noise generated by suction rolls. In Fig. 11 two curves are indicated. In the upper curve is a typical noise spectrum of a noisy machine room. The peak in the 75 to 150-cycle octave band is caused by suction pumps which are operating in the basement of the building. The peak in the 1000-cycle area is caused by the suction roll noise. The noise patterns in operating areas vary all the way from the upper curve, which is a very noisy machine area, to the lower curve which represents a very quiet machine room. In the latter case these sound levels were taken in the aisle between two high-speed machines. If the vacuum pump and the suction roll noise are corrected the loudness reduction is 60%. If only the suction roll noise

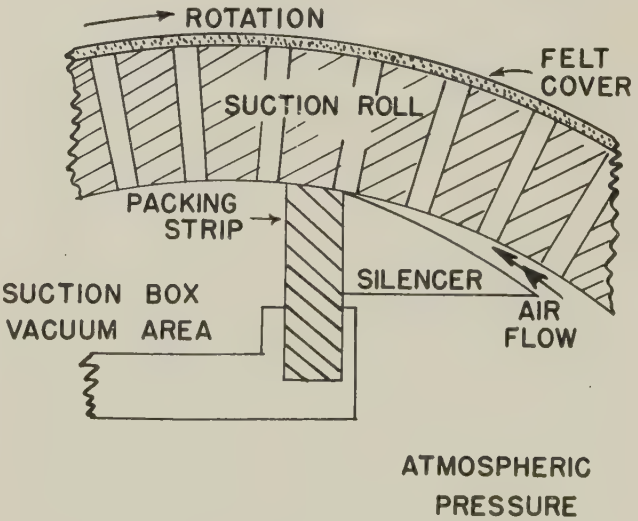

Fig. 12. The Abbott and Krause silencer

is eliminated the loudness reduction is 53%. The reduction in the suction roll noise is here accomplished by means of the Abbott and Krause suction roll silencer. Although this silencer has been discussed before (*6*), it may not be out of place to review once again just what it does.

The discovery of this silencer was made by the late E. J. Abbott who, after some early consulting for Kimberly-Clark, was retained by the Beloit Iron Works to work on the suction roll noise problem. Mr. Abbott observed that when a suction box is rotated so that the dry side seal is at the point where the felt unwraps the suction roll the noise is reduced. From this experiment he concluded that the noise could be reduced if the rate at which air is permitted to enter the evacuated holes is controlled. This he accomplished by the addition of a silencing strip to the trailing edge of the suction box. This type of silencer is shown in Fig 12. The silencer is made of the same material used in the seal strips. It is cut to have the same radius as the inside of the shell. Its center is offset so as to provide a crescent-shaped gap between the inside of the shell and the silencer strip. The air entering the holes must pass through this gap which decreases to zero opening as the holes of highest vacuum are approached. This restricted passage slows the inrush of air to the holes of the suction roll and causes a gradual change in air pressure in these holes. This gradual change in pressure produces no noise. On the basis of some simplifying assumptions Mr. Abbott was able to calculate the gap dimensions to keep the noise to a minimum. If the gap is larger than the calculated value, air will rush in and build up a pressure in the hole giving a sound wave in much the same fashion as the sound wave is produced when no silencer gap is present. If the gap size is too small there will not be enough air entering the holes to bring them to atmospheric pressure by the time the holes reach the edge of the silencing gap. There will then be a situation where a small residual vacuum will be released abruptly and noise again will be generated in the usual way. From their theoretical equation Abbott and Krause suggest the gap size given by:

$$G = 0.43L\,(KV)^{01.7}$$

G is the maximum gap opening in inches
L is the length of the gap in inches
V is the individual volume of the holes in cubic inches
K is a constant which depends on speed (K = 0.8 above 1500 f.p.m.)

It is necessary to point out that the silencing action is based on the principle of the control of air rushing into the holes after they have been evacuated by the suction box vacuum. If we intend to do this controlling on the inside of the roll by means of a silencer strip, the holes must be covered at the other end or no silencing action is obtained. This cover may be a nip, felt, sheet or even a wet wire.

In an experimental roll it was possible to vary the gap size by as much as ±50% from the theoretical with negligible effect on the silencing efficiency. Any attempt to alter the shape of the gap increased the noise output and the gap geometry described above, when positively adhered to, was effective in practical applications. To maintain this shape on producing machines it has been found advantageous to make the silencer strip integral with the suction box seal. When a silencer is first installed, the silencer-seal combination must be cut to fit the contour of the roll and the silencer gap must be carefully shaped. A template laid across the suction box seals guides the workman in this operation. Since the size of the gap can be varied it is possible to start out with a gap which is slightly larger than theoretical. Normal wear does not seem to interfere with silencing efficiency. About once every year the silencers are redressed as part of the regular maintenance schedule. In this operation material is removed from the gap portion of the silencer while the seal portion which is worn into the roll is not touched. This insures a continued good vacuum when the roll is reassembled.

Fifty-five of these silencers have been installed on suction rolls of Yankee-type lightweight tissue machines. In every case where sufficient felt wrap is available to cover the silencer, the suction roll noise has been eliminated.

The tissue machines on which the silencer gap has been so successful carry top and bottom felts and use 100% chemical pulp. When attempts were made to use this silencer principle on other machines which carry groundwood, it is found that the gap silencer still reduced the noise by the amount expected from the experience on tissue machines. However, in couch rolls the draw line and rewetting of the sheet are very sensitive to the vacuum conditions on the dry side of the suction box. Uneven draw lines and uneven sheet wetting have resulted in costly reductions in production when silencer strips were installed. In press rolls where groundwood is present, it appears that felts have a greater tendency to plug when a silencer is used.

Obviously there is not enough theoretical and experimental knowledge of the exact state of affairs at the leaving seal of a suction roll. We have hopes that once this knowledge is obtained we may be able to operate gap silencers successfully on newsprint and book machines.

To attack the suction roll noise problem at its source the gap silencers must be made to work or some other method of controlling air flow into the suction roll holes found for it is well established that this is the source of the noise. If the noise is not controlled here at the source we are faced with a variety of draperies, housings, sound absorbers, and ear protectors to block or absorb the noise before it reaches the operators. None of these methods are as effective as silencing at the source.

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The Sulzer System of Water Extraction for Paper Machines

ROBERT THOMANN

The use of turbo-blowers instead of the conventional volumetric pumps for aspirating air from paper machines has been made possible by the development of effective separators for air and water mixtures. Turbo-blowers have many advantages for this application. Multistage units can be used for central aspiration from all the suction points of the paper machine. Power requirements are lower than those of liquid-ring pumps, and the work of compression can be utilized in the form of heat. As the blower characteristic is fairly flat, the pressure and suction quantity are automatically adapted to prevailing conditions. Drive is by electric motor through step-up gearing, or else by steam turbine which allows of interesting combinations, especially in large mills. While the layout of the blower plant requires wide experience and careful study, all installations so far in service have attained in full the good results expected of them.

THE general fuel shortage which accompanied World War II was experienced in a particularly acute form in Switzerland, a country which depends in this respect almost exclusively on imports; industries, public undertakings, and private households were thrown back on the available hydroelectric power resources. The consumption of electricity rose rapidly in consequence, so that the supply soon became inadequate and severe restrictions had to be imposed. The Swiss paper industry was among the sufferers.

Endeavors had been made for some time to reduce heat consumption in paper machines, and the new restrictions led the paper mills and the suppliers of their equipment to investigate with even greater care every means of cutting down the heat and power requirements per ton of finished paper. The results arrived at deserve closer examination.

There were two ways of setting about the problem: (1) to extract as much water as possible at the wet end of the paper machine and to do this in the most economical way; (2) to improve the efficiency of evaporation of the remaining water at the dry end.

The second of these propositions was tackled by trying to recover and make use of the latent heat of the vapors rising from the drier part. This interesting and important development, however, is not the subject of this paper, which will be confined to measures taken at the wet end.

WATER EXTRACTION AT THE WET END

The extreme importance of extracting as much water as possible is generally recognized, as the heat consumption at the dry end of a paper machine is directly proportionate to the quantity of water to be evaporated. If the specific water quantity to be evaporated at the dry end is plotted as a function of the dry content of the sheet leaving the wet end, it can be established that for each additional per cent dry content a saving of about 4.5% of the steam quantity can be effected.

While the installation of suction presses always leads to increased dryness after the last press, the improvement of water extraction in modern machines is a more difficult matter. There remains, however, the interesting possibility of raising the efficiency of this water extraction; it is then not only a matter of extracting the maximum amount of water, but of doing this with a minimum expenditure of power.

Water was originally removed from the paper web by the use of suction boxes with barometric legs, later by reciprocating, rotary, and other volumetric pumps, and finally by liquid-ring pumps. Water and air were drawn off at the same time, a procedure which inevitably entails a relatively low efficiency in the liquid-ring pump.

In view of this latter fact, the separate aspiration of air and water was introduced and led to a certain though not very marked improvement in the energy balance sheet of the paper machine.

THE TURBAIR BLOWER

A decisive step was taken by Sulzer Brothers, who introduced turbo-machines in place of liquid-ring pumps. Quite a few important reasons speak for this change. The adiabatic efficiency of turbo-machines is considerably higher than that of liquid-ring pumps, with the result that a considerable saving can be made on the power input. In addition, the heat of compression generated in the blower can be employed at the dry end of the machine, and this naturally improves the overall heat balance very considerably. In fact, practically the whole of the energy supplied to the blower can be recovered, and the plant thus offers very favorable prospects for the rapid amortization of the initial outlay.

From the physical point of view, such a blower is nothing but an open heat pump drawing the cold air from the suction boxes and suction rolls and expelling it in the hot state into the drier part. The cycle is closed again by way of the atmosphere.

The Water Separator

The use of turbo-blowers was made possible only by the provision of highly efficient cyclone water separators which permit the separation of water and air between the suction points of the paper machine and the blower. The high efficiency of these units is essential in order to prevent the slow building-up of deposits in the blower ducts by materials such as fibers, fillers, or size dissolved in or carried by the water.

To make sure that no drops of water can find their way into the blower, the last droplets are centrifuged out in special separators installed after the main separators. These drop separators have given efficient opera-

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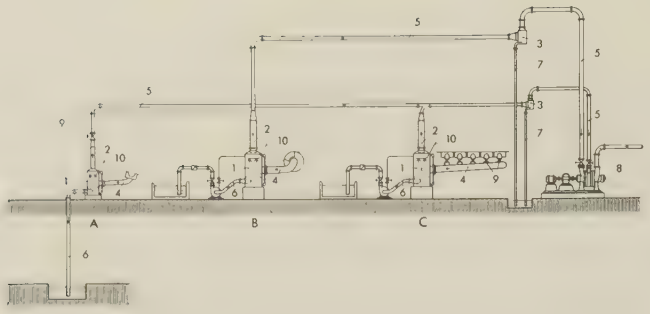

Fig. 1. Fundamental arrangement of the water and drop separators in a central aspiration plant for paper machines, incorporating a Turbair blower

1, main separators; 2, vertical drop pipes; 3, Sulzer-van Tongeren drop separators; 4, suction pipes for air-and-water mixture; 5, air pipes; 6, water pipes; 7, drop leg from drop separator; 8, hot-air pipe; 9, regulating valves; 10, injection nozzles; A, separator for felt suction boxes; B, separator for suction couch roll; C, separator for wire suction boxes.

tion *without exception*, though it must be pointed out that ordinary commercial separators would not do, and that the units employed are the outcome of careful designing work in the laboratory. Figure 1 shows the general layout of the separators.

Central Aspiration

The vacua required in paper machines depend to a large extent on the dry content of the paper web. The following values approximately cover the whole range of European practice:

Wire suction boxes	5–10 in. Hg
Suction couch roll	14–22 in. Hg
Suction presses	17–22 in. Hg
Felt suction boxes	3– 5 in. Hg
Felt washer vacuum boxes	5– 8 in. Hg
Suction shoes of Vickery conditioners	7–17 in. Hg

The conventional arrangement either provides individual vacuum pumps for each suction point, which leads to quite an extensive pumping plant, or alternatively all the suction points may be connected to a central pump. In the latter case the pump must always generate the highest vacuum required and, to enable the requisite vacua to be obtained at the different points, air inlets or throttling devices have to be fitted. These of course involve fairly high losses.

With the Sulzer Turbair blower, on the other hand, central aspiration is possible without losses from throttling, since multistage machines are used.

As intermediate branches can be fitted, every suction point in the paper machine can be connected to a suitable branch of the blower. A central plant can be erected to operate almost without loss either with a single blower or with two blowers working in series or in parallel. Such a plant offers obvious advantages over one employing a number of volumetric pumps, and its upkeep is also very much simpler.

INSTALLATION

Figure 2 is a diagram of a plant of this kind in use with a paper machine having two suction presses. The various suction points, the piping connecting them to the central blower plant, the intermediate preseparators and the cyclone separators are all shown. The effective separation of air and water already mentioned enables the blower to draw in saturated air at the temperature of the paper stock.

Factors Affecting Input

The air, which is initially saturated with water vapor, is heated and dried by compression in the blower, which it therefore leaves with a very low relative humidity, usually less than 1%. The dew point corresponds roughly to the temperature at the wet end. Figure 3 shows how the final temperature rises with rising vacuum. The three curves in the graph are for initial temperatures of 60, 90, and 120°F. To take an example, if the initial temperature of the saturated air is 60°F. and the vacuum 20 in. Hg, a final temperature of 325°F. will be attained, with less than 1% relative humidity. In practice these temperatures are reduced by the aspiration of cold air from other suction points through the intermediate branches.

As stated above the air drawn in by the blower is saturated with water vapor. The higher the vacuum and the temperature at the wire, the greater is the partial pressure of this water vapor. The percentage of the vapor by weight may take on fairly high values and in some circumstances may be of the same order of magnitude as the weight of the air.

However, the vapor as well as the air must be compressed from the prevailing vacuum to atmospheric pressure which represents a considerable extra load on the blower as compared with the delivery of dry air. If the input of the blower is to be kept within moderate limits, the water content of the air must therefore be reduced *before* it enters the blower, i.e., after it has left the separators. This can be done by injecting cold water which condenses part of the water vapor contained in the air. Water injection of this kind is often desirable for other reasons, viz., to eliminate traces of

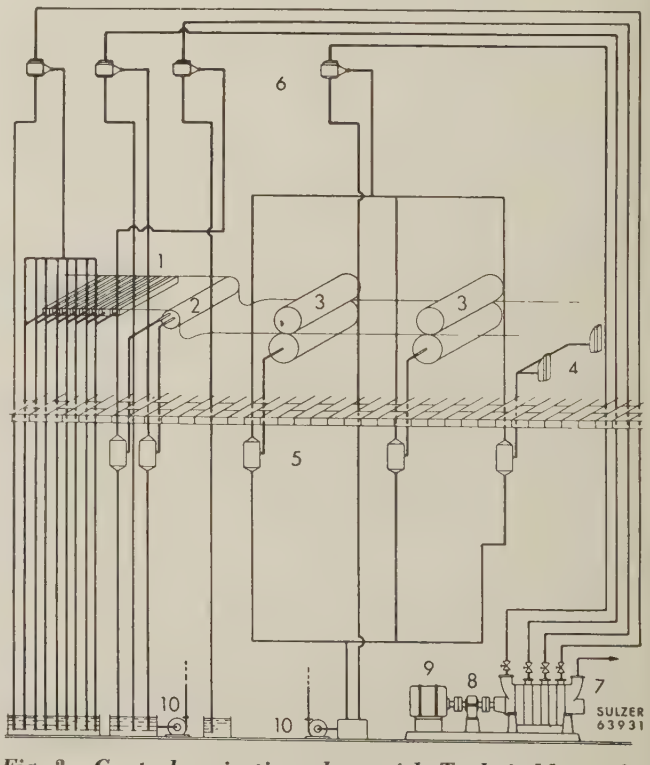

Fig. 2. Central aspiration plant with Turbair blower for a paper machine

1, wire suction boxes; 2, double-box suction couch roll; 3, felt suction press rolls; 4, vickery shoes; 5, main separators; 6, drop separators; 7, Turbair blower; 8, speed-increasing gear; 9, driving motor; 10, pumps.

acids in aggressive air mixtures. Injection nozzles are used in the same way for combating froth formation in the separators, particularly in the making of high-grade, highly sized papers. The air thus treated assumes a temperature very near that of the injection water, a point which is of special importance in paper machines operating with high wire water temperatures.

Figure 4 shows the water content as a percentage of the weight of the dry air at 60, 90, and 120°F. This percentage rises rapidly with vacuum and with temperature. In other words, it is an advantage to keep the temperature of the air aspirated as low as possible, or if necessary to cool the air down. Thus the water content is reduced from 33 to 3.5% of the weight of the air at a vacuum of 20 in. Hg and with cooling from 120 to 60°F. This diagram permits the input for compression at various degrees of air humidity to be determined, as illustrated in Fig. 5. If the input for saturated air at 60°F. is taken as unity, the input for a vacuum of 20 in. Hg and a temperature of 120°F. is 1.6. Conversely, if the air is cooled from 120 to 60°F.

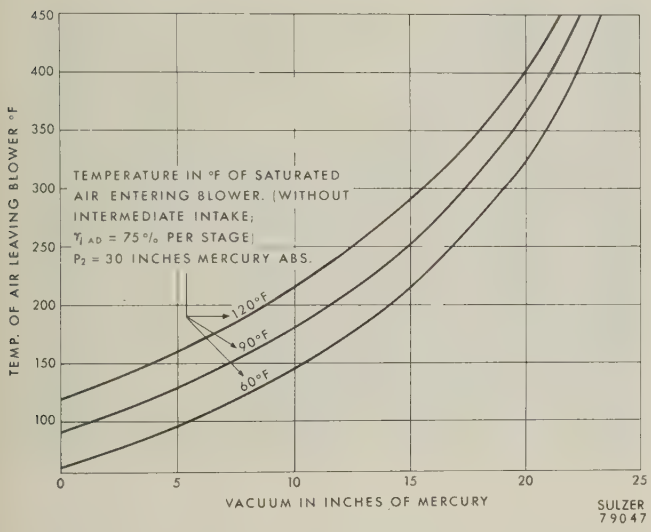
TEMP. OF AIR LEAVING BLOWER °F
TEMPERATURE IN °F OF SATURATED AIR ENTERING BLOWER. (WITHOUT INTERMEDIATE INTAKE; $\eta_{i\,AD}$ = 75% PER STAGE)
P_2 = 30 INCHES MERCURY ABS.
120°F
90°F
60°F
VACUUM IN INCHES OF MERCURY
SULZER 79047

Fig. 3. Final temperature after compression of initially saturated air in relation to vacuum

the input is reduced to $^1/_{1.6}$ = 0.62 of what it would be at 120°F. It is clear from these figures that it is advantageous to keep the temperature and thus the humidity of the air as low as possible.

Heat Recovery

The recovery of the heat of compression is of vital importance for the thermal economy of the whole installation. The hot air can be used either for drying the felts or for preheating the paper stock on the wire, though the commonest method of using this heat is to add it to the hot air supply in the drier section. Here it absorbs moisture and gives up 70 to 80% of its heat, which is in this way recovered. A few figures will be given later to illustrate this process.

Another point which should not be forgotten is that the hot air provided in this way is completely pure and free from oil, having been washed and filtered during its passage through the paper. In the blower itself it does not come into contact with any greased or oiled surface since the bearings are fitted outside the body of the blower. The air may therefore be used without

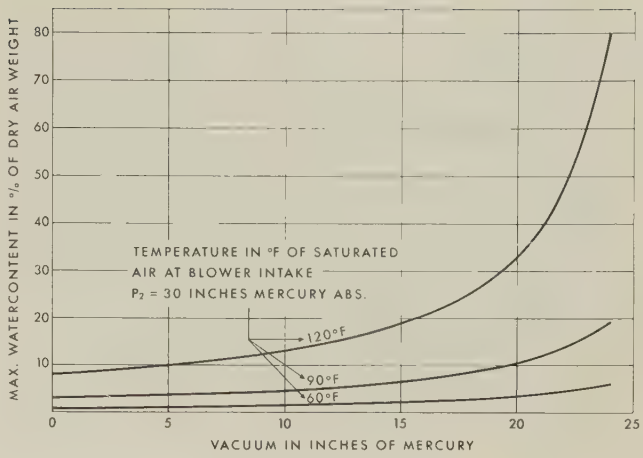
MAX. WATERCONTENT IN % OF DRY AIR WEIGHT
TEMPERATURE IN °F OF SATURATED AIR AT BLOWER INTAKE
P_2 = 30 INCHES MERCURY ABS.
120°F
90°F
60°F
VACUUM IN INCHES OF MERCURY

Fig. 4. Water content of saturated air in per cent of dry air weight in relation to vacuum

hesitation for the direct treatment of even the most delicate grades of paper, and will also lengthen the life of felts which are dried with it.

CHARACTERISTICS OF THE TURBAIR BLOWER

The characteristics of Turbair blowers differ markedly from those of liquid-ring pumps, being much more favorable for practical purposes. The volumetric pump draws in an almost constant air quantity, quite regardless of the prevailing vacua, or in other words its delivery-volume chracteristic is steep in the practical working range. Turbo-blowers have a much flatter characteristic, as shown in Figs. 6 and 7, so that the quantity of air drawn in varies in accordance with the vacuum, decreasing when the vacuum rises and increasing when it falls. This is most convenient, as it corresponds exactly to the practical requirements of the paper machine. Heavy papers or those consisting of very slow stock, which have normally to be manufactured at low speed, require higher vacua and less air than light porous papers. The latter can be run through the machine at very high speeds, but this demands the aspiration of much greater quantities of air at low vacuum. The Turbair blower thus adapts itself automatically to the air requirements, whereas

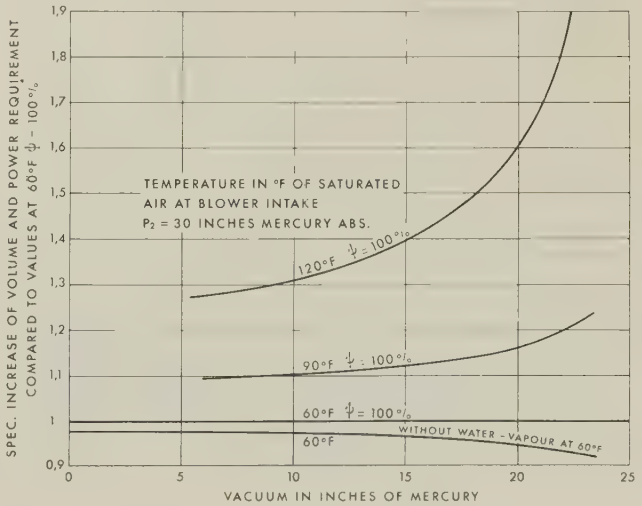
SPEC. INCREASE OF VOLUME AND POWER REQUIREMENT COMPARED TO VALUES AT 60°F φ = 100%
TEMPERATURE IN °F OF SATURATED AIR AT BLOWER INTAKE
P_2 = 30 INCHES MERCURY ABS.
120°F φ = 100%
90°F φ = 100%
60°F φ = 100%
60°F
WITHOUT WATER - VAPOUR AT 60°F
VACUUM IN INCHES OF MERCURY

Fig. 5. Increase of volume at blower intake and power requirements for compression of saturated air at constant dry air weight, in relation to vacuum. The value at 60°F. is taken as unity

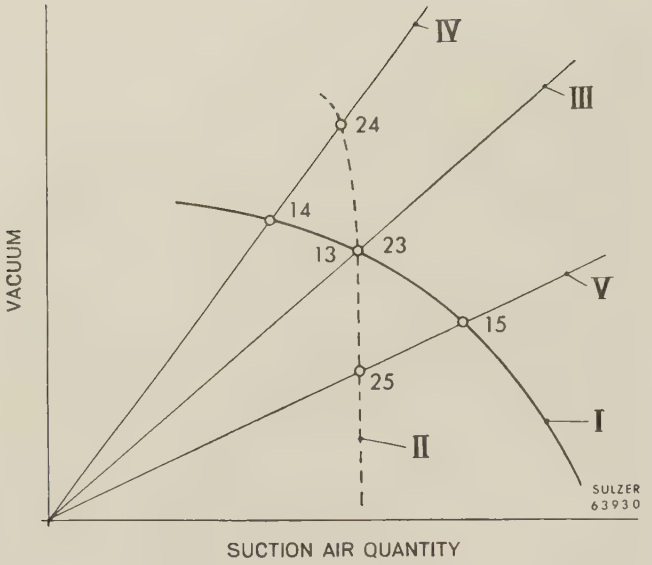

Fig. 6. Fundamental characteristics of a Turbair blower and a liquid-ring pump

Curve I: Characteristic of a Turbair blower. Curve II: Characteristic of a liquid-ring pump. Curve III: Resistance of a paper of average porosity. Curve IV: Resistance of a paper of low porosity. Curve V: Resistance of a paper of high porosity. Points 14, 13, 15: Vacuum obtained with a Turbair blower for papers of various porosity. Slow variation of vacuum. Points 24, 23, 25: Vacuum obtained with a liquid-ring pump for papers of various porosity. Rapid variation of vacuum.

volumetric machines must be laid out and operated for maximum vacuum. A limited adaptability is obtained by throttling, but at the expense of efficiency.

Power Saving at Couch and Less Wire Wear

The great differences in vacuum which occur in liquid-ring pumps increase the friction between the wire and the wire suction boxes, and with it the output required of the driving motor for the suction couch roll. This has a very adverse effect on certain papers and naturally increases the wear on the wire. For this reason liquid-ring pumps usually have to be fitted with vacuum limiting devices, which again give rise to energy losses that can be avoided with the Turbair blower.

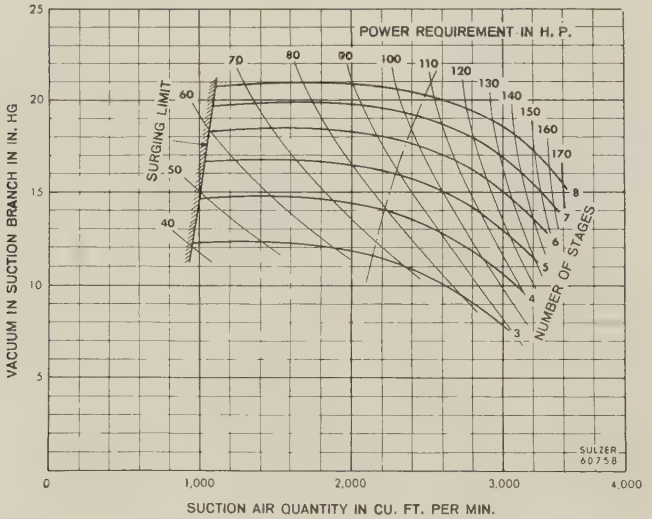

Fig. 7. Characteristics of Turbair blower KRC 45-20 when used as a vacuum pump

Suction temperature 60°F. Pressure in discharge branch 30 in. Hg. Speed 7000 r.p.m.

No Water Required

Unlike a liquid-ring pump, a blower requires no make-up liquid, a point which is of importance wherever water is in short supply or the temperature of the available water is too high. The bearings only require a small amount of cooling water which carries away not more than a few per cent of the heat equivalent of the blower input.

Simplicity of Construction

With regard to the appearance of the Turbair blower, Fig. 8, it was essential that a machine intended for paper mill duties should be sturdy and simple throughout. The Sulzer Turbair blower can safely claim to meet these requirements in all respects. It closely resembles a multistage centrifugal pump, and any mill engineer and maintenance man will at once be familiar with it. Its runners and blades have been designed in the light of the most recent advances of aerodynamic research and have been submitted to thorough tests

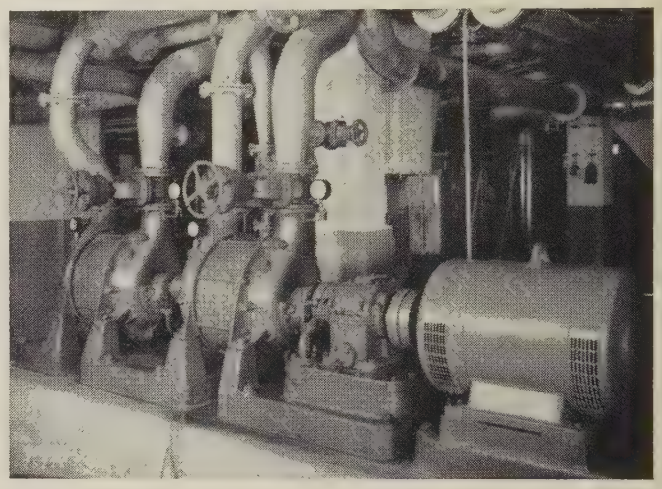

Fig. 8. Tandem arrangement of two Sulzer six-stage Turbair blowers supplied to a Swiss board mill

Vacuum 19 in. Hg. Delivery quantity two 120 c.f.m. under suction conditions. Speed 9000 r.p.m.

in the laboratory. These tests have been verified in actual service with over 200 units. Every part is designed for uninterrupted operation, such as is customary in paper mill practice.

The casing consists of single segments held together by strong tie-bolts. Up to eight stages may be provided, as conditions require. Each stage comprises the runner and a two-piece casing element designed as a diffuser and cross-over piece leading to the next stage. The first and last stages are fitted with connecting branches, while the other stages can be furnished with intermediate branches as desired.

Figure 9 shows a blower with one intermediate branch in the dismantled state. The simple construction of the machine is at once apparent, and in particular the fact that its stages consist of identical segments. In Fig. 8 a complete set with driving motor and step-up gear is illustrated. In this case there are two intermediate branches.

Advantages of Steam Turbine Drive

Figure 10 shows a blower driven by a back-pressure

steam turbine, an arrangement which has much to recommend it when steam power is available, particularly in large plants. The gear is no longer necessary and the turbine drive permits speed regulation within certain limits. The vacua can consequently be very accurately adjusted to the conditions of service and to the type of paper being produced.

Operation in Series

In some cases, and in particular when the resistance of the felts fluctuates within wide limits, it is preferable to connect the wire and felt parts separately to the aspirating plant. In this case two blowers can be arranged in parallel with a common drive. Figure 11 shows such a set.

The wire suction boxes and the suction couch are then connected to the blower for the wire part, the presses and the Vickery conditioners to the blower for the felt part. Another alternative is a common aspirating plant in which automatic regulators are provided in the suction lines from the presses in order to control the vacuum.

Sulzer Brothers build two sizes of type KRC Turbair blowers. These are quite sufficient for service with

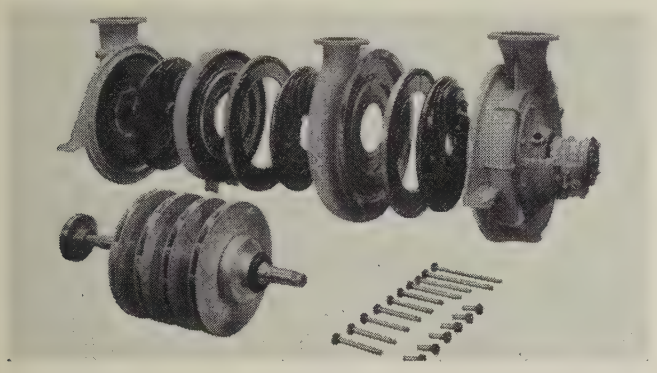

Fig. 9. Sulzer four-stage Turbair blower in the dismantled state

small and medium paper machines. Machines with wire widths of over about 100 in., however, require several Turbair blowers, or otherwise large turbo-vacuum blowers of the RC type must be used.

Adaptability of Turbair Blowers

These figures are only limiting values. But as any number of stages up to eight can be employed, all possible working conditions between the limiting values given can be attained. Since the blowers are composed of standard components, they can be modified simply and rapidly if it should prove in service that practical results do not correspond with the assumptions made for the project. The intermediate branches can be shifted in order to obtain an increase or decrease of vacuum corresponding to one stage. It is also a simple matter to add or to remove one or more of the intermediate stages, at least as far as the maximum number of stages allows. With the use of a second shaft, a further blower can be added and the vacuum in this way raised, as shown in Fig. 11.

Large paper or cellulose machines, and high-speed newsprint machines in particular, require large turbo-vacuum blowers designed to meet individual operating conditions. While fundamentally similar to Turbair blowers in their use and their qualities, they differ

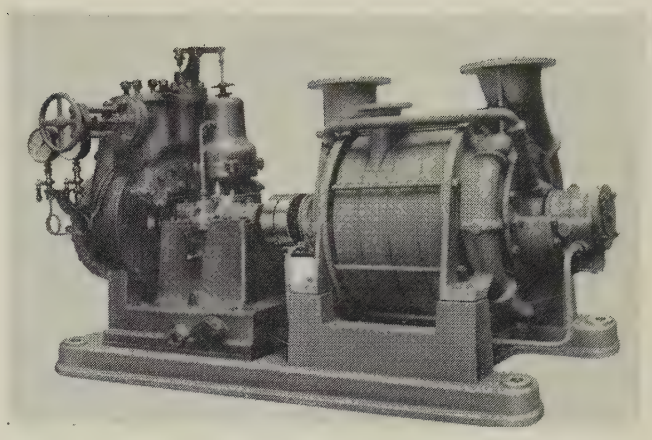

Fig. 10. Turbair blower direct coupled to a Sulzer back-pressure steam turbine

considerably in construction, so that a short description of them is perhaps called for.

Design of the Large Vacuum Blowers

The cast-iron casing is horizontally split at the height of the blower axis Fig. 12. This design gives the casing great rigidity which is very important at the peripheral speeds and capacities in question and greatly contributes to the quiet running of the machine. Upkeep is also simplified by this design, as the internal parts are readily accessible, when inspections or overhauls have to be carried out, by simple removal of the top part of the casing. The runners are built up of forged steel components, as is usual in modern compressor construction, and give the blower high specific efficiencies. From the point of view of strength, these runners are the sturdiest that can be made. In spite of the considerable speeds the safety factor is therefore very high and the severest requirements can be satisfied with regard to reliability and durability in service.

Regulation of the Large Blowers. In large installations the blower is furnished with a vacuum control system which acts upon a throttle valve fitted in the air pipe from the suction presses and thus automatically keeps the vacuum at the suction inlet of the blower to a predetermined level. If paper breakage should occur between the suction couch roll and the suction presses, this control system maintains the vacuum in the suction pipe of the presses and thus prevents the sudden increase in delivery, with overloading and consequent cutting-out of the driving motor, which would other-

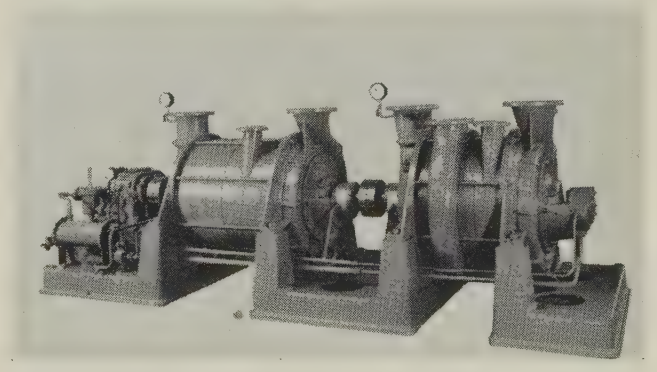

Fig. 11. Tandem arrangement of two Sulzer Turbair blowers (six and eight stages) for a paper mill

Vacuum 18 in. Hg. Delivery quantity two 120 c.f.m. under suction conditions. Speed 7000 r.p.m.

wise result; at the same time the vacua at the suction couch roll and the wire suction boxes are maintained unaltered and the operators can give their full time to the paper machine.

Particulars Required for Calculation

The various air quantities cannot be determined in advance with any degree of certainty, as up to the present too few results are available from the builders of paper machines with regard to the coefficients of paper resistance as a function of porosity, weight, and dryness. Originally, an attempt was made to get over this difficulty either by altering the speed of the blower, when working conditions made this appear desirable, or by calculating the data on the basis of results obtained with existing paper machines. It is easy to measure the vacuum during service; determining the quantity delivered is a much more difficult matter.

Practical experience shows that there are great differences in the design and operating conditions of the various types of suction equipment used on paper machines. The air flow figures also differ, and it is impossible to set up any general values. These figures depend to a large extent on the following details of design: (1) the wire width, (2) the weight per unit area of the paper, (3) the speed of the machine, (4) the number and dimensions of the wire boxes and the suction boxes of the other suction points.

For technological reasons the following properties of the stock, which greatly affect porosity, also have to be taken into account: (1) the quality of the stock (freeness); (2) the weight, quality, and condition of the felts used; (3) the temperature of the stock (viscosity);

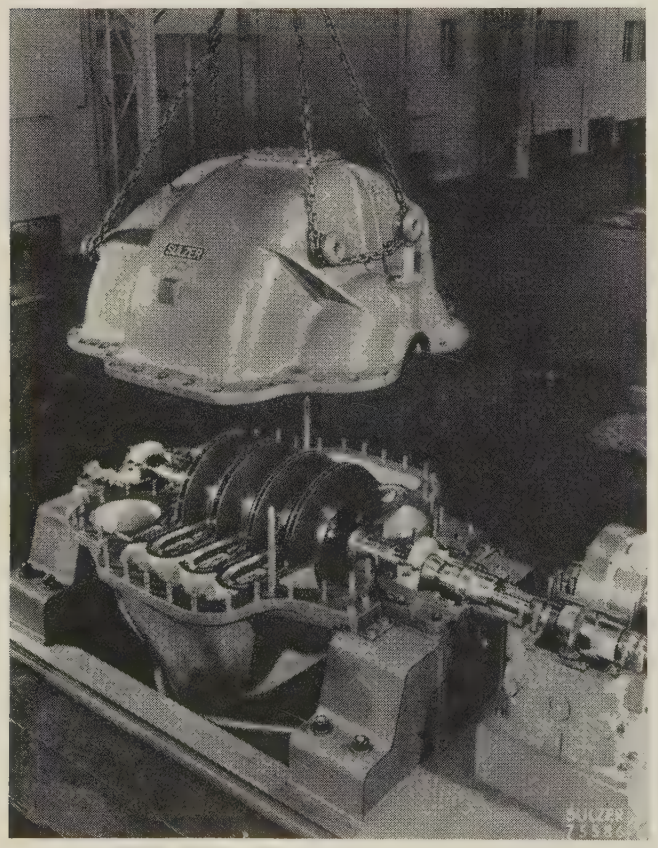

Fig. 12. Sulzer four-stage radial blower with gear for a paper mill in Finland

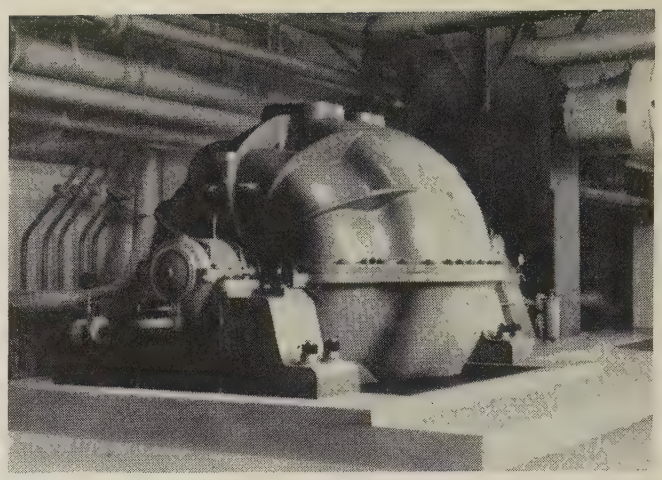

Fig. 13. Sulzer five-stage radial blower for a German paper mill

(4) the dry content to be attained; and (5) the quantity of paper to be manufactured.

It must also be considered that production figures, dry content, machine speed, and vacuum or air flow are all interconnected. The lower the speed of the machine and the higher the vacuum (or the air quantity extracted), the more effective will be the drying process.

This makes it clear that it is a very difficult matter to estimate the operating data of a blower installation, especially when accurate data on the paper machine are not available. The best plan is to have such data supplied by the makers of the paper machine.

COMMERCIAL INSTALLATIONS

The first experimental plant was put into service in the Netstal Paper Mill, Switzerland, in 1944; it was used with a machine having a wire width of 85 in. and equipped with a suction couch roll. Since that date the blower has been in continuous service and has given excellent results. In 1945 a second blower came into operation in the same mill and has run up to the present without giving the slightest trouble.

The installation of this latter blower in place of the liquid-ring pump previously used made a power saving of 58% possible, which in itself permitted the capital outlay for the blower to be written off within 2 years. The air heated by compression is blown below the dry end. If account is taken of the heat energy recovered in this way, the expenditure for the blower was fully amortized within 12 months.

Economy of operation naturally depends directly on the prices of fuel and electric power and thus differs from plant to plant. In another Swiss paper mill, for instance, the power input for four liquid-ring pumps had been 345 hp. The blower which has now replaced them requires 260 hp., or in other words a saving of 25%, i.e., 85 hp. has been made. The hot compressed air leaving the blower at 285°F. is mixed with the warm air supply to the dry end and cooled down to 95°F. so that 88% of its heat is recovered. In this way the equivalent of $0.88 \times 260 = 230$ hp. is saved, making an additional saving of about 580,000 B.t.u. per hr. On the assumption of a working period of 7000 hr. per year, the outlay for the plant can be covered in 2 years at the most.

In new plants, where only the extra price paid for a blower as compared to a liquid-ring pump has to be

amortized, the situation is obviously still more in favor of the turbo-blower.

Well over 200 blowers have been supplied up to date, some of which have been in service for a number of years. The orders have come in from most countries of the world.

The favorable results so far obtained cover a range of production extending from cellulose wadding and tissue paper to the thickest board.

The blowers are also suitable for use in the cellulose industry, where they serve, as with the paper machine, to generate the vacuum needed for draining the cellulose.

In this branch blowers have been operating in Sweden for 5 years past, and new units are at present being built for higher vacua.

The first blower of the high-speed type to be installed in a paper mill has now been in practically uninterrupted service for 5 years without the slightest trouble being encountered. At the present moment 30 of these blowers, with a total input of nearly 16,600 hp., have been delivered or are under construction for paper mills alone Fig. 13. The largest blower so far supplied, working on a Bagley and Sewall newsprint machine with a production of 300 tons per day, requires 1700 hp. for a total suction volume of 40,000 c.f.m. and a maximum vacuum of 21 in. Hg.

CONCLUSION

Summing up it may be said that Sulzer blowers have already taken their place in the paper industry and have passed their tests with outstanding success. Their technical and economic advantages are such that they are not only an excellent investment in new plants; in many instances they also make the replacement of existing liquid-ring pumps an attractive and thoroughly justifiable proposition.

A Sulzer water extraction plant is the modern way of dewatering the paper web; it allows better control of the plant, is easy to maintain and requires less space than the orthodox method using individual pumps.

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DISCUSSION

Curt A. Young (Chairman, TAPPI Drying and Ventilating Committee; Manager of Engineering, Riegel Paper Corp., New York, N. Y.): The application of the high-speed centrifugal vacuum pump on paper machine service is still in its infancy in the United States. Rotary-type pumps have been most frequently used with some reciprocating pumps and very few centrifugal pump installations.

The paper industry, which is certainly vigorous and alive to constant improvement in operating efficiencies, has had good reasons until now for the selections that have been made. We say "until now" because we know that the spirit of progress in our industry is very much evident in the plants built in recent years and new ideas are welcomed by our technical men.

Mr. Thomann has made an excellent case for the centrifugal vacuum pump. His paper is full of facts and based on good experience in the paper industry. He and his associates are deserving of our utmost respect and attention. In the interest of bringing about a sound discussion we will point out some factors that Mr. Thomann may have overlooked, or at least minimized.

What are the considerations that have guided American paper mill engineers into what is probably a more conservative practice than is prevalent in Europe? They are as follows:

1. Paper mills in this country represent huge investments. A 30 million dollar plant may be required to support one paper machine. Plant operating personnel are most unhappy when equipment selection leaves them with all of the eggs in one basket. Vacuum pumps have, therefore, been selected to reduce to a practical minimum vulnerability to complete shutdown.

2. Reliability of operation figures heavily in the plant designer's selection of equipment. Machinery rotating at 7000 to 9000 r.p.m. is special equipment and must be treated as such. Personnel skilled in the operation and maintenance of this new equipment is a requirement to safe and uninterrupted operation. At present, the electrician, mechanic, pipe fitter, instrument mechanic, and turbine operator give valuable service and assistance to the paper machine operators. In most American paper plants this new equipment would not be the responsibility of the paper mill crew. It would be interesting to know how this responsibility is treated in the European mills.

3. Maintenance requirements are another important item. Corrosion problems may be severe, particularly where paper grades are run at low pH, erosion problems cannot be overlooked at these high rotational speeds and maintenance of perfect lubrication is imperative. Down time for maintenance and inspection must be regularly scheduled for this type of equipment, if for no other reason than for safety and maintaining efficiency of the runners and diffusers of the unit. Most of us would classify the present rotary-type vacuum equipment as a reliable work horse requiring very little maintenance.

4. Simplicity and ruggedness, coupled with good efficiency have characterized the plant designer's selection of equipment. This has resulted in the machine crew getting as familiar with the vacuum equipment as it is with the fourdrinier, the presses, or the reel of the paper machine. The centrifugal machine inherently does not have the advantage of this simplicity, consisting of numerous segments held together by tie rods. For the larger units the cast iron casing is split, resembling more the powerhouse turbine. Also we must consider the complications of a turbine drive, gear unit, main and auxiliary water separators, water pumps, and vacuum control system required in the case of a motor-driven installation.

Flexibility and interchangeability of vacuum equipment between paper machines and mill departments are important considerations. All of you know that paper machines are speeded up sometimes to double the initial design conditions, paper grades run on the machine are radically changed and fourdrinier and press components added or eliminated as the case may be. The rotary vacuum equipment now in use permits a high degree of flexibility so that problems arising as a result of a machine rebuild or an emergency condition are solved

in a practical manner. This flexibility extends also to the prime mover for the vacuum equipment. In the cases mentioned above the steam and power balance may be seriously upset, requiring costly changes to the driving turbine.

6. The power saving possible with the centrifugal vacuum pump is of real interest to all of us. Actually the main point of Mr. Thomann's paper is that his equipment can pump air at less cost than with rotary-type equipment. Where power costs are high, as they are in Europe, this can be a very significant factor. A large paper machine installation may make a power saving of 400 hp. a definite possibility. With power cost figured at 1 cent per kw.-hr., based on 8500 hr., this amounts to $28,000 per year, which is a very sizable figure.

7. The utilization of the heat in the atmospheric discharge from the blower is quite interesting. However, it can only amount to about 1 to 1.5% of the total heat expended in the drying operation on the machine. Certainly it is worth going after. In order to keep our sense of perspective this represents as much heat as could be saved if the press operation on the paper machine were improved by 0.2%, that is, instead of entering the driers at 70% moisture we enter at 69.8% moisture.

8. The vacuum-capacity characteristic for the centrifugal vacuum pump is excellent, particularly on the suction box section of the paper machine. The capacity of the centrifugal machine varies in accordance with vacuum. It is apparent that some improvement in wire life could be effected, also beneficial effects with regard to speed regulation of the driving motor should result. Mill engineers have wrestled with this problem for years, but much remains to be done.

9. The capital investment required has not been mentioned, so we do not know whether this is more or less than for present equipment. This would depend on the specific project but it is an item that cannot be overlooked. Fixed charges such as interest, depreciation, insurance charges for direct and consequential damage, use and occupancy coverage, and operating charges for maintenance and inspection are important cost considerations which may cut into the power savings considerably.

10. In the main, paper mill managements have stressed points as previously outlined; namely, vulnerability to complete shutdown, reliability, maintenance, and operational requirements, simplicity and ruggedness, flexibility and interchangeability, economy of operation with attendant advantages to paper machine operation, investment requirements, fixed and operating costs in which, of course, is included the power cost.

A single large paper machine may produce in 24 hr. $45,000 worth of newsprint or kraft paper and $90,000 worth of kraft liner board. Equipment of utmost reliability and performance is the only common sense rule. Pulp and paper mill engineers will welcome the serious introduction of this new and proven equipment into our industry. They are anxious for improvements in our plants that will produce more production at less cost. They will ask the questions that have been outlined above and the answers must be not in technical niceties but an economic evaluation, practical and down to earth. I am sure that those who want to do business in our industry welcome such an approach.

H. J. Buncke (Oxford Paper Co.): I have read the comments by Mr. Young, chairman of the Drying and Ventilating Committee, and would endorse the comments which he made dealing with the adaptation of the Sulzer vacuum system compared to those systems which are established in use on paper machines in the United States and Canada.

It is the writer's opinion that, in the final analysis, the economy of any unit suggested for adoption in American papermaking practice, will be the controlling factor in the adaptation of such a unit. The economy must reflect the net annual return in the process function, giving due weight to the capital costs required and final operating cost per ton of paper. Included in the over-all economy must be the penalty of lost production which may be experienced by unplanned outage which reduces the tons of paper produced for sale.

For the reasons which were well outlined by Mr. Young, centrifugal vacuum equipment, to the writer's knowledge, has been little used in this country for wet end vacuum service on paper machines. A change from the equipment now used would necessitate some careful research work carried out on operating units making use of the Sulzer vacuum system. Such studies may illuminate all the influencing factors which must be met by the Sulzer vacuum system as compared with the equipment now in general use for the services concerned.

R. Thomann (Sulzer Bros. Ltd.): Mr. Curt A. Young's remarks are most considerate and constructive and I wish to thank him for his contribution.

The following comments on his discussion may be useful:

1. Not a single case is known to us where a paper machine had to be shut down because of a failure of the blowers. Some minor difficulties were experienced with the first installations, but all these troubles have been overcome years ago.

2. The reliability of blower plants is extremely high and in European paper mills the foreman is responsible for both the paper machine proper and the blowers. This has proved to be entirely satisfactory. Furthermore, the blowers are equipped with safety devices throttling the plant automatically when a sheet breakage occurs.

3. Where corrosion is to be encountered the water separators are equipped with spray nozzles to lower or increase the pH value of the air. A plant in Finland is run with a pH value of 2.8, but no corrosion whatsoever has been experienced.

Erosion is non-existent since the blowers are working on air which has been washed in the separator.

Many plants have been run for several years without any overhaul and it can be considered as a safe rule that an overhaul should not be made more often than every 2 years.

4. It is beyond question that a blower plant is more elaborate than a number of liquid ring pumps. It must, however, not be forgotten that all elements of a blower are very ruggedly built in accordance with designs known long ago. Similar speeds are commonly found in steam turbines and gears used all over the world. The personnel get acquainted with blower plants in a very short time and no difficulties have been experienced in Europe in this respect.

5. Central blower plants with one single machine serving the complete paper machine are the exception. For paper machines with a width of over 120 in. the wire part and the press part are connected to separate machines. They are generally built in such a way that both machines are identical and in case of shut down of one of the blowers the paper machine could be run on one single blower at reduced production. In some cases, a third blower is kept as a stand-by.

6. With a power cost figured at 1 cent per kw., the cost of a blower plant can be written off in a reasonable time. European conditions are quite comparable with those in the States.

7. An economy of 1 to $1^1/_2\%$ of the total heat expended seems to be low, but is actually very high when expressed in dollars. I wonder how it would be possible to improve the press operation by 0.2%? Even if it were possible it would still be worthwhile to save the 1 to $1^1/_2\%$ heat by using a blower plant.

8. Speed regulation is not so important with centrifugal blowers as their characteristic curve is very flat. However, it would be interesting to use speed regulation for the blowers serving the presses in order to limit the power intake in case of a paper breakage. Throttling would then become unnecessary, but speed regulation is generally just too expensive.

9. The capital investment depends mainly on the existing layout of the mill, but it can be stated that roughly speaking the investment for a blower plant is about 30 % higher than the investment for liquid ring pumps.

10. Mr. Young's general remarks apply to both American and European plants. I may point out that in Finland a paper machine with a production of 100,000 tons per year is served by one single blower and in another mill two similar machines are equipped with two blowers each. The experience with these machines has been most outstanding and has fully come up to expectations.

Five Year Investigation of Digester Corrosion by the TAPPI Chemical Engineering Subcommittee

J. R. LIENTZ, S. J. BAISCH, H. O. TEEPLE, and N. SHOUMATOFF

Five years ago the TAPPI Chemical Engineering Committee formed a subcommittee to study corrosion problems in alkaline digesters. A great number of reports, data sheets, and technical programs have been presented to keep the alkaline pulp industry informed of the scope of the problem and the corrective steps which might be taken. It is the purpose of this report to condense the available facts and opinions to a single concept of the complex digester corrosion problem. The over-all problem has been considered from the standpoint of (1) its economical importance, (2) its theoretical background, and (3) its practical control. The conclusions reached as a result are: (1) The general level of digester corrosion in the industry is not now economically serious, even though some individual mills may face a serious problem. (2) In alkaline pulping conditions, steel is normally protected from appreciable corrosion by a passive surface film. However, this film is subject to discontinuous breakdowns of limited scope resulting from mechanical, thermal, chemical, and electrochemical conditions, and especially from the nonuniformity of these conditions within the digester and during the cooking cycle. (3) Effective control of corrosion in actual digesters is provided by conscientious use of the TAPPI system of digester care, which makes possible the identification of critical conditions and the concentrated application of corrective and preventive maintenance where it is needed. The concept of alkaline digester corrosion now held by the committee is that a safe and economically low rate of metal loss is properly considered a normal condition. Higher rates of attack do exist in limited frequency of occurrence and may be considered deviations from the normal. Such accelerated attack occurs only under special conditions which are identifiable and therefore controllable. Even the most refractory corrosion problems can be subdued by a conscientious fact-finding approach followed up by appropriate constructive action.

FIVE years have elapsed since the TAPPI Chemical Engineering Committee formed its Subcommittee on Digester Corrosion, which has now been given enlarged scope and status as the new Corrosion Committee. The current projects have been completed and the committee is starting new ones, not only in digester corrosion but on other problems as well. It seems appropriate at this transitional stage to present a report summarizing the results of the past 5 years of intense committee activity.

These results have already been presented individually. From the beginning it was the subcommittee's policy not only to bring new information before the industry immediately but also to use publication media extensively in its deliberate crusade against alkaline digester corrosion. Consequently, it has produced a published record of great magnitude; including programs, progress reports, research reports, discussions, data sheets, individually contributed technical papers, a literature survey, and a monograph (*1–43*, inclusive). Furthermore, the most important of these results have already been condensed in four key publications (*1–4*). The corrosion of alkaline pulp digesters is probably somewhat unique among the industrial corrosion problems in having been studied so intensively and being of common interest to so many pulp manufacturers. The present report, therefore, is not intended to present new information. Its sole purpose is to provide a sense of perspective to reduce the great mass of available facts and opinions to a single concept of the complex digester corrosion problem.

To arrive at such a concept, the problem will be

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reviewed from three different aspects: (1) its economic importance; (2) its theoretical background, and (3) its practical control.

ECONOMIC IMPORTANCE

At the time the subcommittee was formed (in fact, the reason it was formed), corrosion of alkaline pulp digesters was definitely considered to be a major problem, not only in this country but throughout the world. Several factors contributed to this situation and its timing: (1) greatly accelerated corrosion was reported by individual mills, with a few cases of replacement after 2 or 3 years of service; (2) a number of mills, especially kraft mills in the south, built during the 1930's, were having their first experience with digester corrosion which had progressed to points where replacements were necessary; (3) nondestructive thickness testers made it possible to obtain complete thickness traverses of digesters, and first tests frequently revealed serious loss of metal, previously unsuspected; (4) the report of the Swedish corrosion committee (*45*) and its conclusion that higher silicon content of pressure vessel steel increased digester corrosion; (5) the postwar expansion of the pulp and paper industry which resulted in many persons installing new digesters and seeking assurance that they could expect from them a reasonable life; (6) those looking for a solution in the form of alloy protection were confronted with some reports of failure of stainless steel digester linings by both localized metal loss and stress corrosion cracking. It was natural that the increased awareness of digester corrosion problems, resulting from combinations of these factors, frequently produced a state of alarm combined with feelings of helplessness. Such a serious view of the problem was justified. Its urgency was underscored when, soon after the subcommittee was organized, a digester exploded causing two deaths, major property damage, and extended loss of production of a pulp mill.

The subcommittee soon realized that qualitative sporadic information of the types just enumerated did not constitute a valid basis for assessment of the problem, and a factual industry-wide survey was immediately initiated. This survey was inconclusive because it did not yield adequate numerical data regarding corrosion rates (*5*). The subcommittee then emphasized the importance and techniques of obtaining quantitative corrosion data. Within 2 years so much data had been accumulated by the individual mills that a second industry-wide survey of a more analytic type was initiated.

The data assembled included 60,000 individual measurements in 99 different digesters. These figures were adequate for rigorous statistical and time series analysis and constituted a sizable sample of the entire United States industry. However, not being random samples, they were not necessarily representative. The lack of randomness resulted from the fact that the basis for selection was the availability of suitable data. As usual in such cases, one can only speculate as to the probable direction of the bias in the sample, if any. There does seem to be some possibility that mills which had made extensive measurements and were willing to cooperate with the subcommittee may also have been those with more severe corrosion problems. However, the authors feel that if any bias exists, it is of insignificant magnitude.

The nature of the corrosion measurements and the criteria used for their evaluation follow. The data were readings of digester wall thickness (or of alloy lining thickness) taken with a nondestructive electronic instrument. For each digester they were made in sets.

1. Each set corresponds to a single inspection.
2. The inspections were made at time intervals, usually six months.
3. The readings in each set were regularly spaced forming a traverse of the interior surface, with usually about 200 readings per set.
4. At each sequential inspection readings were taken at or very close to the same points as before so that changes could be directly compared as a measure of corrosion rate at each location.
5. The number of available sequential sets varied for the different vessels, from two to eight, two being the minimum accepted.

In evaluating corrosion cost, materials of construction and trends (as distinct from the purely local problem of safety control), the average corrosion rates giving equal weight to all readings made in the vessel were considered to be the most meaningful, as a basis for comparing relative performance over a cross section of the corrosive conditions encountered. When internal corrosion variations were specifically of interest, the ratio of maximum to average corrosion was used as the comparison statistic to eliminate the influence of variations in the general level of corrosion performance.

The observed average current corrosion rates of 86 carbon steel digesters ranged from zero to 0.077 i.p.y. with a median of 0.028 i.p.y. (*3B*). For 13 alloy digesters the rates ranged from 0 to 0.028 i.p.y. with a median of 0.007 i.p.y. In 68 vessels intensity of localized corrosion was expressed as a ratio of the vessel average. The observed ratios ranged from one to 11.9 with a median of 2.4 (*3C*).

It was estimated, using a corrosion rate of 0.031 i.p.y. (*3A*) that the annual United States cost of digester deterioration due to alkaline corrosion was $2,000,000 or approximately $0.22 per ton of pulp (*3A*). This estimate assumed that a digester "can lose one third of its original weight" which made an intuitive assessment of both the prevailing corrosion allowance and the localized attack as it affected replacement. To refine this assumption would be difficult and not worth the effort for the type of evaluation made. Assuming also that the average corrosion rate and localized attack ratio may vary independently of each other from vessel to vessel, it is interesting to show how each of these two factors separately can affect the deterioration cost per ton of pulp.

	General corrosion	*Localized corrosion*
Minimum	$0.00	$0.08
Median	0.20	0.20
Maximum	0.55	1.00

There was a strong negative correlation (0.65) between the average corrosion and the localized attack ratio, so that actually the peak cost lies somewhere between $0.55 and $1.00. These extremes, of which that for localized attack is more readily controllable, indi-

cate that the direct cost of digester corrosion is not one of the major exonomic problems of our industry, amounting in general to less than 1% of total pulp cost. However, in individual mills this problem may be quite expensive if severe corrosion is taking place, especially indirect costs of maintenance and loss of production.

A question of importance in connection with the economic aspects of digester corrosion is whether or not this problem is currently more severe than in the past, and what is its outlook for the future. The belief that digester corrosion has accelerated is almost universally held, and the literature contains many opinions to this effect. However, in the data assembled by the subcommittee it has proved difficult to establish this fact by a clear-cut comparison.

In the subcommittee's first survey (*5*) data from a large number of digesters, but of unspecified area coverage in each one, and with corrosion rates calculated by comparing a measured thickness with the original nominal, showed a strong increase in corrosion for digesters installed since 1940 when compared with older ones. It was concluded, however, that the method of comparison made it impossible to attribute the change to either metallurgical or operating factors. Furthermore, it was not clear whether the rates reported referred to general or localized attack.

In the second subcommittee survey, which was in two parts, the first part showed 17 pre-1940 steel digesters currently corroding at average of 0.026 i.p.y., simultaneously with 38 post-1940 digesters corroding at 0.039 i.p.y. This type of comparison clearly pointed to a metallurgical difference, since operating factors were largely eliminated from the comparison, and agreed with other comparisons made within the same mills.

In the second part of this survey some new data were introduced from one mill which did not support, although it did not contradict these apparently clear-cut results. In spite of this inconsistency, most of the evidence supports the belief that a real change in steels did occur in the immediate postwar period making them less corrosion resistant. Stockman has suggested that this may be due to less pure steel being produced during the war by the use of less pure scrap (*44*). Some of the current superiority of older steels may perhaps be attributed to "survival of the fittest," rather than change in metallurgy. It is not proved, however, that the newest digesters, less than 5 years old, are showing the same accelerated corrosion except in those mills which deliberately changed the steel specifications (*3*).

In the second survey, wherever possible, the current corrosion rates were compared with past rates for the same vessels by projecting back to the original thickness. Seventeen such comparisons were possible, in five different mills. In one mill, three digesters corroded much more rapidly in the period 1945–50 than they have since. In another mill, seven digesters installed in 1937–42 showed accelerated corrosion since 1951, which was correlated with increased pulp production per digester combined with higher sulphidity. The remaining seven digesters in three different mills are corroding now at essentially the same rate as they have since they were installed in 1929–37.

Fluctuations in corrosion showed a positive correlation with sulphidity changes in three different mills, although in all three the sulphidity variations seemed small compared to those in corrosion rates, again restricting the comparisons to the same digesters for the different periods. Presumably this method comparison eliminated metallurgical factors and revealed the effects of operating changes only. However, this severely restricted the amount of usable data and failed to pick up any general increase in corrosion rates which may have occurred in recent years as a result of accelerated cooking cycles and higher sulphidity following process modifications.

On the other hand it does not appear that such acceleration of corrosion, if it existed, has carried on up to the present time. In the second survey, the corrosion rates were re-examined in three mills representing 32 steel digesters, on the basis of new data from late 1953 and early 1954, and in almost every instance the estimated corrosion rates were revised downward. If the subcommittee's program of corrosion control methods, is increasingly successful in the future, as it appears to have been in the immediate past, further reductions in prevalent corrosion rates may be expected.

To keep informed of such changes in corrosion rates, as an index of the current status of the problem and a measure of the success of its work, the subcommittee has initiated a program for periodic evaluation of corrosion conditions and trends on a regional basis (*41*). It is expected that results of these evaluations will be compiled and published regularly.

It is surprising that with such a large amount of quantitative corrosion data already assembled, there is still some difficulty in giving definitive answers to important questions. With the new regional program, additional data will be coming in continuously and it may be found necessary to revise some of the specific conclusions that have been drawn. These interpretations are important because they rest on an increasingly broad factual basis and have contributed much to our over-all concept of the digester corrosion problem.

THEORETICAL BACKGROUND

The committee's sponsored research program was restricted to the survey of conditions at the operational level, and did not include a concerted effort to penetrate into the fundamental natural laws involved, by means of controlled experimentation. However, the subcommittee has sponsored a number of individually contributed papers giving the results of experimental investigations into the nature of digester corrosion. These individual research papers have explored three of the major types of factors involved: metallurgical, physical, and electrochemical. Last October the subcommittee presented a summary of some of these important findings, from the practical point of view, to provide design and maintenance engineers with a check-list of undesirable conditions to be watched for and avoided (*4*). Some of the same ground will be briefly covered again, but from a different point of view —that of synthesizing these various results as far as possible into a single concept of the fundamental mechanism of digester corrosion. This approach may determine how far we have progressed from empirical descriptive knowledge toward quantitative mastery of the subject, and thus indicate what remains to be done as a problem for future research.

The original sources for the most important of these results from a theoretical point of view are four papers sponsored by the TAPPI subcommittee (*6*, *8*, *9*, *43*), three covering work done in Sweden (*44*, *45*, *46*), and one in Canada (*47*). By a ruthless process of simplification, the basic results have been compressed into a few fundamental points: (1) The corrosion resistance of mild steel to alkaline pulping conditions is reduced by certain components in the steel, especially silicon, and/or oxygen and carbon. (2) The surface condition of mild steel can critically affect its resistance to corrosion in alkaline pulping. Corrosion is reduced in areas that are covered with mill scale, with liquor deposited scale, or in those dried in air a long time. It is accelerated in areas that have been scoured, sandblasted, pickled, or subjected to serve mechanical action of liquor or chips during the cooking cycle. (3) Corrosion in alkaline digesters is influenced by concentration of or exposure to certain inorganic and organic chemicals. In particular, it appears that corrosion is accelerated by sodium sulphide, inhibited by sodium polysulphides, and can be triggered to initiate a violent corrosion reaction by exposure to acids and certain organic acid extractives of wood, or air in an impinging jet of liquor. Pure cooking liquors are generally more corrosive than those containing wood chips and spent liquor, so that in most alkaline cooks corrosion decelerates rapidly as the cook progresses. Considerable localized corrosion often occurs even before the actual cook is started, due to splashing of liquor on the hot metal while filling the digester, which results in local increase of chemical concentration and mechanical action due to boiling. (4) Corrosion in alkaline cooking liquors as in other electrolytes can be affected by electropotential differences, but the effects are highly complex and strongly influenced by secondary factors such as surface conditions and polarization. It is not entirely clear whether intensified corrosion due to movement of liquor over a metal surface is the result of increased galvanic potentials or direct mechanical action, or both.

This brief résumé of the results of laboratory investigations and controlled field testing may be further supplemented with three general observations. First, variations in corrosion rates attributable to steel chemistry are much smaller than those which may be produced by the variations in mechanical, chemical, and electrochemical operating conditions. Second, the complexity and occasional inconsistency of results obtained even under controlled laboratory conditions parallels to a considerable extent the difficulties encountered in interpreting the evidence of the uncontrolled field observations. Third, alkaline pulping in digesters is essentially a batch process so that the metal is subjected to a cyclic variation of mechanical, thermal, and chemical operating conditions.

In the application of these results for practical purposes, probably the most useful device is to classify the various factors according to whether they are associated with generalized or localized attack. When the interest is in a fundamental explanation as it is here, an equally powerful approach is to combine these two phenomena, as aspects of a single elementary process differing only in degree. The authors do not consider that erosion as such, in its literal sense of removal of *metal* by abrasion, exists as a significant factor in the digester corrosion problem. This leaves only corrosion in the strict sense which is essentially a chemical reaction between a metal and its environment.

This reaction has mechanical, thermal, and electrical aspects, insofar as they determine the reaction kinetics, according to the principles of physical chemistry. This question of kinetics is of course the most vital one, since our problem concerns the ability of metal to resist the reaction as a function of time. The process of synthetic reasoning can be carried still further, unifying the physical and electrochemical influences under a single concept, namely the conditions at the interface between the solid and the liquid. It is quite evident that this interface is the locus of all variables which can affect the kinetics of the reactions: gradients of temperature, velocity, concentration, and electric potential across and along this boundary. Normally it appears that in alkaline pulping the metals have the ability to build up a membrane of inactive solid material at the interface, probably consisting of products of the chemical reaction, reducing the reaction kinetics to the relatively low level which seems to be most prevalent in actual digesters, in many cases being virtually negligible. However, this membrane or protective film is subjected to both localized and cyclic destructive forces, as well as to attack by certain chemicals, which can thus trigger a corrosive reaction of destructive intensity. From this viewpoint it is concluded that the integrity of the protective film is the most important single factor affecting the ability of the metal to withstand the inherent corrosiveness of the process. The occurrence of the various forces which attack the protective membrane in the course of normal operation are mostly localized to the initial part of the cooking cycle. Thus, the destructive aspects of digester corrosion are distinctly not a continuous process, but a process consisting of discontinuous attacks on the metal. The intensity, frequency, location, and size of these attacks are governed by probability parameters representing the composite effects of the various destructive forces in each individual digester. Thus we have arrived at a concept of digester corrosion from the theoretical point of view which appears to be consistent with all known experimental and observational data that exists in such astounding variety. It is the concept of what Hassler calls "a precarious equilibrium," from which the many apparently inconsistent individual occurrences are deviations which seem to occur at random but in reality are governed by definite laws of probability in each individual digester. The belief that accelerated corrosion can occur only under certain definite conditions makes this concept a reasonable basis for further theoretical and experimental studies.

The basis researches which led to this general conclusion revealed a deficiency of existing knowledge in two major areas: (1) methods of characterizing the condition of the metal surface exposed to corrosion with respect to its measurable degree of passivity in a quantitative sense, and (2) precise determination and logical explanation of the effects of the digester corrosion environment, which presupposes a much more complete knowledge of the chemistry of digester liquors and of the reactions which occur during the cooking cycle than is now available. The committee has recognized the importance of these deficiencies and is considering a

concentrated research effort to overcome them. It is suggested that these studies try to characterize the experimental results in terms of probability parameters as indicated above, as well as in terms of the conventional weight loss corrosion. Such fundamental research will undoubtedly have applications to other corrosion problems in the industry.

PRACTICAL CONTROL

The investigation of the industry-wide economics and trends of digester corrosion and its theoretical background are essential for a sound approach to the problem from a long-term viewpoint. However, the immediate need of digester owners is to control corrosion in actual digesters and to establish safety from digester explosions. The subcommittee did not accept direct responsibility for the exercise of corrosion control in the field, as it is felt that this responsibility should belong only to the individual operators. Nevertheless, this aspect of the problem did occupy a great part of the committee's attention in determining proven techniques of corrosion control and publicizing them to the industry.

The initial effort in this direction was the preparation of a data sheet for use by inspectors in obtaining, recording, and interpreting data on the exact status of corrosion in a digester (*10*). The principles of this data sheet have remained the basis for the elaborate and effective system of field corrosion control which the committee has since formulated. This system involves the following elements: (1) an efficient instrument for measuring wall thickness at a large number of points, (2) establishment of a reproducible rectangular grid for routine repetitive measurement of thickness at fixed points giving an adequate representation of the entire digester wall, (3) a graphic method for recording of visual observation of corrosion conditions for direct comparison with the measured thickness, (4) a procedure for determining the critical area in the digester as the basis for the safety valve setting, and for predicting remaining service life or repair schedules.

The basic ideas of the data sheet were not original with the committee, as they were in regular use in at least two pulp mills before the subcommittee was organized. It is indebted to Crossett Paper Mills and Union Bag & Paper Corp. for the original development of these modern inspection techniques and to Branson Instruments Co. for developing the widely used thickness tester, the "Audigage" (*11*).

The use of these techniques spread rapidly and experience with them was accumulated in large quantity. As a result, the subcommittee was soon confronted with the need for a more complete and detailed exposition of the inspection procedures than in the original data sheet. This task was undertaken energetically and resulted in the publication of the full length TAPPI Monograph No. 12 (*2*) to which practically every committee member contributed one or more chapters. This monograph has become the keystone of the program for practical control of digester corrosion, as well as the basis for the regional evaluation program already mentioned.

The central principle of this corrosion control system is the identification of a "critical area" in each digester as the focal point of attention and constructive action. This implies scrutiny of data in *all* areas in the digester so that the critical area may be identified by a process of selection and comparison. This procedure assures that the various parts of the vessel will receive attention in proportion to its need, so that resources will be directed in the most efficient manner toward achieving control of the local corrosion problem.

In principle, the critical area is the one most likely to corrode first to the point where a reduction of operating pressure will be required. Because of an element of statistical error in the thickness measurements which the committee has investigated in great detail, the actual identification of this area is not simple. Several possible criteria and techniques were experimented with in the hope of finding one that is realistic, adequately provides for the statistical element, and is simple to apply. It is felt that the method finally arrived at meets these requirements. This defines the critical area as the area of minimum remaining corrosion allowance referred to the safety valve setting plus hydrostatic head. Thus thickness, rather than local current corrosion rate, is used as the identifying criterion, because the corrosion rate estimate is subject to much larger percentage error than thickness. Also, if there should be some other area actually corroding so that it will reach the minimum allowable more rapidly than the one selected, it will in time be identified as the one with minimum remaining corrosion allowance. Thus, the identification of the critical area becomes more certain at the same time that the condition of the individual digester becomes more critical.

Having identified the area requiring attention, the system next calls for the inspector to analyze the data as to the extent of corrosion damage, cause of attack, and the predicted remaining service life, and to take the necessary corrective action. Such action may take the form of local repairs or changes in equipment details or operating procedure to remove the cause of localized attack. A method of repairing critical areas by stainless steel overlay as developed by Hopper (*2*) has proved to be a valuable method for control of digester corrosion when used in connection with the described procedure of identifying these areas. Also the numerous causes of localized attack discussed by Parker (*4*) provide a sound basis for constructive modifications with an excellent prospect that any severe localized corrosion condition may be brought into a state of satisfactory control. The committee is also working on the standardization of design to eliminate features in new digesters which experience has shown to be sources of trouble.

Having identified and brought under control the conditions at the critical area, the inspector is then in a position to consider the possible need for further steps to reduce corrosion of a more general type. Such action may take the form either of changes in process chemistry or of the replacement or field protection of the digesters with alloy construction. Although such further steps may be necessary only when the general corrosion itself approaches a critical intensity, definite improvements have been obtained in individual mills and may serve as a basis for more general application in the future. Changes of these types must be evaluated in terms of relative economies applicable to each particular case. This aspect of the problem is closely identified with the

data on superior corrosion resistance of certain alloys indicated by the committee's industry-wide survey, as well as by its plans for further studies in the chemistry of corrosive liquors, and for the standardizatoin of digester design details.

The system for control of corrosion in actual digesters, incorporating the features mentioned above and formulated in detail in the TAPPI Monograph, has proved by experience to be highly effective. The development of this system by the committee, in conjunction with the techniques developed in individual mills, is undoubtedly its major contribution to the practical knowledge of the digester corrosion problems. It has brought the most troublesome phase of this problem within the scope of successful preventive maintenance.

CONCLUSIONS

The general conclusions of the three preceding sections may now be summarized:

1. Although some acceleration of digester corrosion may have occurred since 1940 for both metallurgical and operational reasons, this acceleration has apparently decreased and the general level of digester corrosion in the industry is not economically serious, even though a limited number of mills may face a serious problem.

2. In alkaline pulping conditions, steel is normally protected from appreciable corrosion by a passive surface film. However, this film is subject to discontinuous breakdowns of limited scope resulting from mechanical, thermal, chemical, and electrochemical conditions, and especially from the nonuniformity of these conditions within the digester and during the cooking cycle.

3. Effective control of corrosion in actual digesters is provided by conscientious use of the TAPPI system of digester care, which makes possible the identification of critical conditions and the concentrated application of corrective and preventive maintenance where it is needed.

These three conclusions have a common theme which leads directly to a single unifying concept of the entire digester corrosion problem. In digester corrosion a safe and economically low rate of metal loss is properly visualized as a normal condition. Higher rates of attack do exist but they have a limited frequency of occurrence and are properly visualized as deviations from the normal. Such accelerated attack occurs only under special conditions which are identifiable and therefore controllable. Even the most refractory digester corrosion problems can be subdued by a conscientious fact-finding approach followed up by appropriate constructive action.

In its future work with digesters and other problems, the TAPPI Corrosion Committee hopes to receive the same degree of enthusiastic cooperation and support from the industry as has been enjoyed by the original digester corrosion subcommittee of the TAPPI Chemical Engineering Committee during the past 5 years.

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Correlation Between Chlorine Number and Lignin Content of High-Yield Kraft Pulps

E. L. KELLER and PETER B. BORLEW

The suitability of a rapid chlorine number method as a mill control method for measuring the degree of delignification of high-yield kraft pulps was studied by determining the chlorine numbers and lignin contents of samples of 12 commercial pulps of this type. These pulps ranged in lignin content from 8 to 14% and in chlorine numbers from 10 to 18. Dependence of chlorine number on lignin was linear, the correlation coefficient being 0.998. The method appears suitable for mill use.

THE trend toward the production of high-yield kraft pulp, especially for liner board, is well known. The high-yield kraft pulping process is a modification of the usual sulphate process in which milder cooking conditions are used and the softened chips are fiberized in the presence of the hot spent liquor. However, these conditions are somewhat more drastic than those used in producing the still higher yield kraft semichemical pulp. Owing to the relatively high lignin content of the pulps, the permanganate number test was found unsuitable as a test for degree of delignification. The reasons for this have been discussed previously (*1*), when it was also brought out that the Bathurst Power Paper Co., Bathurst, N. B., was using an adaptation of the Roe chlorine number as a routine control test in producing high-yield kraft pulp. It was reported that the test could be made in 30 min. The Bathurst modification differs from the TAPPI Standard for determining the chlorine consumption of pulp only in the use of sheeted instead of fluffed pulp. This test has also been used at the Fernandina Beach, Fla., mill of the Container Corp. of America since midsummer of 1953. Limited results obtained with the method have been published (*1*, *4*).

Because of the promise shown by the Bathurst method as a generally satisfactory mill control test, the Alkaline Pulping Committee of TAPPI obtained a research grant to explore the correlation between the chlorine number and lignin content of a variety of commercial high-yield kraft pulps. Supervision of this study was placed with its High Yield Kraft Lignin-Chlorine Number Correlation Subcommittee. This subcommittee arranged for the work to be done at the U. S. Forest Products Laboratory, in close cooperation with the chairman of the subcommittee. The results of this investigation are reported here.

E. L. KELLER, Chemical Engineer, Forest Products Laboratory, maintained at Madison, Wis., in cooperation with the University of Wisconsin, Forest Service, U. S. Department of Agriculture, and PETER B. BORLEW, Associate Technical Director, National Container Corp., Jacksonville, Fla., formerly Technical Superintendent, Container Corp. of America, Fernandina Beach, Fla.

This study was made in cooperation with the Fundamental Research Committee of the Technical Association of the Pulp and Paper Industry under Research Grant No. 46.

SCOPE OF THE INVESTIGATION

Samples of 12 high-yield kraft pulps were supplied by mills ranging geographically from Florida to Canada and to the West Coast. These samples provided variation in species, presumably in pulping practice, kind of refining equipment, and point of sampling after refining. The procedure for chlorine absorption (Roe number) that had been selected was similar to TAPPI Standard T 202 m-45, except that lightweight pulp sheets were used instead of fluffed material. Lignin was determined by TAPPI Standard T 222 m-52, but modified by use of acetone in place of alcohol-benzene for the extractant, as suggested by Jensen (*3*), because of the preponderance of pines.

Because of the anomalies often found on applying indirect measures of lignin to high-yield pulps, some of the filtrates from the lignin determination were tested for presence of "acid-soluble lignin."

DESCRIPTION AND PREPARATION OF THE PULPS

A description of the pulps tested is given in Table I, with average values for their lignin contents and chlorine numbers included for reference. The lignin content of the commercial high-yield kraft pulps tested ranged from 8.1 to 13.9%. Two experimental pulps of 2.97 and 21.6% lignin were also tested to estimate the direction of the correlation line beyond the limits of lignin content of the commercial pulps. The pulp of lower lignin content was made from southern pine, and the other from jack pine. Hardwood fiber was reported to be present in only one instance (pulp 12, Table I). This pulp was a semichemical kraft made from a mixture of 90% gum and 10% of other southeastern hardwoods. As is well known, the lignin in hardwoods differs markedly in chemical composition from that in softwoods.

Although the pulp samples 1 to 6, inclusive, Table I, were understood to have been screened at the mill, many large fiber bundles (shives) were present. The pulp samples 7 to 10, inclusive, had not been screened. These were evaluated as received and also after screening on a small, flat, pulsating screen fitted with an 8-cut plate. The screened portions are identified by the designation "-s" in Table I.

The commercial pulp sample 11 was divided into several portions for comparative analyses at the U. S. Forest Products Laboratory, and at the Bathurst Power & Paper Co., Ltd., which supplied the sample. This experiment will be described in detail later.

With one exception, a portion of pulp no. 11, all samples were air-dry when received. These were dispersed by prolonged soaking in hot water, followed by attack with a high-speed stirrer. The samples were

then brought to about 25% consistency and divided into two parts. One portion of each sample was air-dried and put through a Koerner mill to provide fluffed pulp for the lignin determination. The other portion was stored in a sealed container at 35°F. to be made up into sheets as required for the chlorine-number determination.

The descriptions of the pulps given in Table I were furnished by the mills providing the samples.

METHODS OF ANALYSIS

Chlorine Number

To obtain the chlorine number a sample of moist pulp sheets was permeated with chlorine gas at atmospheric pressure for 15 min. At the end of this time, the volume of gas taken up was measured and calculated to grams of chlorine consumed per 100 grams of moisture-free pulp.

The apparatus conformed to that illustrated in TAPPI Standard T 202 m-45, except that TAPPI stopcock S_2, located close to the reaction chamber, was replaced with a two-way stopcock by which the reaction bottle could be vented directly into the room. As a precaution in this particular investigation, an additional stopcock was placed just before the inlet to the reaction chamber. This was to prevent absorption by the pulp by diffusion of the chlorine in the connecting tubing leading to the burets during the 5-min. preconditioning time. The cock was kept closed while the sample was preconditioned. Gas volumes were measured with a 100 and a 200 ml. gas buret connected in parallel. With this arrangement, a full 2-gram sample could be used with pulps of somewhat more than 25-chlorine number.

Before operations were started, the connecting tubing was checked for leaks and the solutions were tested for saturation with chlorine. Blank determinations, using filter paper, were made at the start and at the end of each day's work. The blank ran about 0.7-chlorine number. Just before starting the first chlorination, the liquor level in the right arm of the gas pipet was adjusted to a convenient reference mark on the capillary tube by lowering the leveling bottle and closing stopcock S_2.

The step-by-step procedure in making a determination was as follows:

1. A number of test sheets (7.5 lb. per 1000 sq. ft.) were formed on a small sheet machine. The sheets were dried at 105° C.

2. The equivalent of 2 grams of moisture-free pulp sheet was weighed out. A variation of 10 or 20 mg. was not considered significant provided the true weight was known. (For control tests an oven of the "quick consistency" type is convenient for both rapid drying and weighing.)

3. The weighed sheets were placed between wet blotters, and the sandwich was put through an ordinary hand-operated clothes wringer in order to remoisten the sample. The test sheets were stripped from the blotters and placed on a balance, where the total weight was brought to 4.5 grams with distilled water from a medicine dropper. The sheets were crinkled so that the gas could quickly reach all parts of the sample. The last half-sheet was used to wrap them loosely into cylindrical form.

4. The sample was immediately put in the reaction chamber of the apparatus, and the chamber placed in the water bath. Because of the difference between the ambient temperature (26°) and the temperature of the bath (20°), plus the fact that a change in temperature of 1° in a volume of 100 ml. would lead to an error of 0.4 ml. of chlorine, the chamber was allowed to stand, vented to the room, for 5 min. before chlorine was admitted.

5. During this 5-min. preconditioning, the contents of the gas burets were displaced to the atmosphere through the two-way cock, after which the stopcock was reversed and the burets filled to a point past the 100-ml. mark with fresh chlorine from the tank. The stopcock was then changed back to the vent position

Table I. Lignin Content and Chlorine Number of Several Commercial High-Yield, Hot-Refined, Kraft Pulps

Sample no.	*Species*	*Origin*	*Sampling point*	*Lignin content, %*	*Chlorine no.*
1	Pine	Western Florida	Decker	8.32	10.64
2	Pine	North Carolina	Decker	7.86	9.69
3	Balsam (70%) Spruce (30%)	Canada	Decker	12.23	14.97
4	Pine	Pacific Coast	Decker	8.63	10.83
5	Pine	Western Florida	Decker	10.27	12.47
6	Pine	Canada	Decker	10.97	13.46
7	Pine	Eastern Florida	Last-stage washer	10.27	12.80
7-s	Same as 7, but laboratory-screened			9.91	12.46
8	Pine	Eastern Florida	Last-stage washer	12.01	14.76
8-s	Same as 8, but laboratory-screened			11.61	14.35
9	Pine	Eastern Florida	Last-stage washer	12.13	15.38
9-s	Same as 9, but laboratory-screened			11.76	14.70
10	Pine	Eastern Florida	Last-stage washer	13.91	17.40
10-s	Same as 10, but laboratory-screened			13.24	16.68
11	Balsam (70%) Spruce (30%)	Canada	Decker	13.10	16.73
12	Hardwood, 90% gum	North Carolina	Decker	13.12	16.79

and the liquid level brought exactly to the 100-ml. mark with the leveling bottle. The cock was then closed.

6. The reaction chamber was sealed, then the stopcock connecting the reaction chamber and the gas pipet opened so that chlorine gas was drawn from the buret to the pulp chamber. The leveling bottle was raised to keep the levels in the two arms of the gas pipet substantially even as the gas was absorbed. (Comparable results are obtained if the reaction bottle is hung up in a fixed position. Suitable chlorine-resistant tubing was not used in this installation, however, and it was realized that loss through any undetected pinhole leaks would be minimized if the operation were carried out at atmospheric pressure.)

7. The chlorine was permitted to remain in contact with the pulp for exactly 15 min.

8. The liquid level in the pipet was returned to the mark on the capillary by lowering the leveling bottle, and the stopcock leading from the reaction chamber to the pipet was closed. The burets were leveled and the readings taken.

9. The chlorine number was calculated using the formula given in the TAPPI method. (Charts could also be prepared from which the chlorine number may be read directly.)

Determination of Lignin Content

Since lignin content was determined by TAPPI Standard T 222 m-52, slightly modified, the details are not included here.

The prolonged soaking in hot water required for dispersion of the air-dry samples was considered to be a sufficient substitute for the hot-water extraction described in the TAPPI method for semichemical pulps. It was observed that the water drained from the pulps after dispersion was highly colored.

The substitution of acetone for alcohol-benzene as an extractant was satisfactory from an operating standpoint. The hydrolyzates filtered normally, with a slight turbidity manifest on only one or two occasions. Results of a few comparisons of the two extractants indicated no important difference between corresponding lignin values.

Examination of the Lignin Filtrates for Acid-Soluble Lignin

Several of the filtrates from the above lignin determinations were treated with sodium hydroxide to pH 11 to 12 in the expectation that any acid-soluble lignin present would be precipitated. Heating the solutions for a few hours just below the boiling point led to the formation of a dark color and the precipitation of a brown floc. The supernatant liquor was decanted after several hours of standing. Final separation of the floc was made on a fritted-glass crucible. The precipitate was washed with 0.2*N* NH_4OH, dried at 105°C., and weighed. Amounts recovered on pulps 1 through 4, inclusive, and also on 12, ranged from 0.4 to 0.5% on the original pulp.

Analysis of the residue for methoxyl groups gave a negative result. Another portion of the precipitate was treated at room temperature with an excess of sodium hypochlorite in acid solution. The material consumed only 15% of its weight in chlorine, compared to about 120% that lignin will normally consume.

It appeared unlikely that acid-soluble lignin was present. Since a satisfactory correlation between TAPPI lignin and chlorine number was developing, it was deemed unnecessary to apply other techniques, such as those developed by Campbell and McDonald (*2*), to pursue further the question of acid-soluble lignin.

DISCUSSION

A linear relationship between the chlorine numbers and the lignin contents of the pulps is shown in Fig. 1.

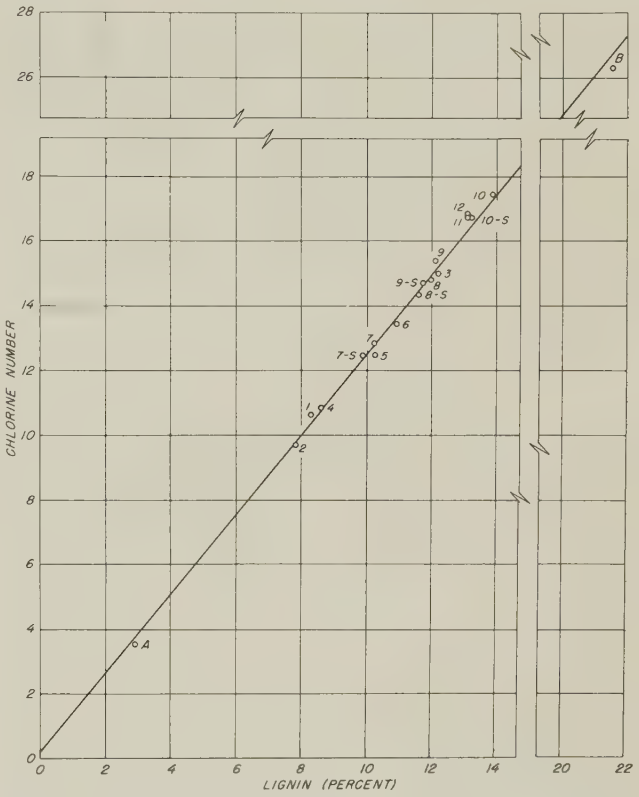

Fig. 1. Correlation between chlorine number and lignin content of several commercial high-yield kraft pulps and two experimental kraft pulps

The line in this figure was drawn from a regression equation calculated from the average values for the commercial pulps given in Table I and the averages for the experimental pulps A and B, Table II. This equation giving regression of chlorine number on lignin content is:

$$\text{Chlorine number} = 0.1851 + 1.2290\% \text{ lignin}$$

The corresponding correlation coefficient is 0.998; and the standard error of estimate, 0.2774.

Individual test values are given in Table II. From these, standard deviations for the lignin and chlorine-number methods as limited to this study were calculated according to Youden (*6*). These are 0.1480 for the lignin method and 0.1031 for the chlorine-number method. Difference in precision was not found to be significant at the 0.05 level.

Within the limits of the present data, lignin content as a function of chlorine number is expressed as follows:

$$\text{Per cent lignin} = (0.8108) \cdot (\text{chlorine number}) = 0.1096$$

Appreciable amounts of shives can be present without

Table II. Individual Test Values for Lignin Content and Chlorine Number for Several Commercial High-Yield Kraft Pulps and Two Experimental Kraft Pulps

Sample no.	Lignin content, %	Chlorine no.	Sample no.	Lignin content, %	Chlorine no.
1	8.14, 8.49	10.64	8-s	11.38, 11.71, 11.74	14.35, 14.35
2	7.73, 7.88, 7.97	9.66, 9.72	9	12.18, 12.15, 12.05	15.40, 15.37
3	12.26, 12.13, 12.30	15.07, 14.87	9-s	11.79, 11.73	14.75, 14.64
4	8.61, 8.74, 8.54	10.81, 10.85	10	13.71, 13.88, 14.14	17.31, 17.50
5	10.17, 10.30, 10.35	12.41, 12.52, 12.47	10-s	13.18, 13.30	16.66, 16.69
6	11.06, 10.76, 11.10	13.45, 13.46	11	13.13, 13.09, 13.07	16.80, 16.65
7	10.30, 10.28, 10.23	12.83, 12.78	12	12.97, 13.25, 13.13	16.57, 17.06, 16.74
7-s	9.72, 10.03, 9.99	12.42, 12.49	A	2.90, 3.04	3.56, 3.54
8	11.96, 11.84, 12.22	14.81, 14.72	B	21.61, 21.37, 21.87	26.28, 26.31

interfering with the result. The four pulps, 7 to 10, inclusive, were received and tested in an unscreened condition. They were also tested after passage through an 8-cut flat screen. Removal of the large fiber bundles decreased the percentage lignin content by 0.5, but this did not upset the relationship, for the chlorine numbers decreased proportionately. Accordingly, the points for the unscreened material fell as closely to the line as those of the same pulps after screening (designated by "-s"). This is a definite advantage, since where the method is used for control purposes, little time can be spent in processing the sample.

However, if unscreened pulp is sampled for testing, knots and the unusually large shives comprising mill rejects should be removed before testing, since they would interfere in the preparation of the very lightweight sheets. Probably screening with use of a 20-cut plate in the control laboratory would be satisfactory. Possibly the best point for sampling is after the decker, especially in those operations where the highly lignified knots and other rejects are refined and returned to the system. The decker sample is, of course, representative of the material from which the board is ultimately made.

The estimated time requirement, previously mentioned, of 30 min. for a determination was taken from an earlier publication (*1*). The time was based upon the method as described by the Bathurst Power & Paper Co., Ltd. (*5*). In that version, a 5-min. preconditioning time was not included, and the drying temperature for the pulp sheets was probably above 105°C. The preconditioning time can be eliminated by selecting a suitable location in terms of ambient temperature, or else by precooling or prewarming the sample bottles as necessary. The question of the most efficient sheet weight can be investigated to establish the optimum balance between the number of sheets required to be made, their drying time, and adequate penetration of chlorine. If time is critical and the pulps run uniform in moisture content, it is possible that moisture determination and chlorine number can be run simultaneously on separate samples.

As previously mentioned, an interlaboratory testing comparison was made by the U. S. Forest Products Laboratory and the Bathurst Power & Paper Co., Ltd. Pulp for this purpose was taken after the decker at the mill. Handsheets were made from the slush pulp at Bathurst, one portion being tested there and the other portion at Madison. Also at Bathurst, another part of the slush pulp was air-dried, reslushed, and made into handsheets, which were then tested by both laboratories. Still another portion of the slush pulp was supplied to the Forest Products Laboratory, and was dealt with as just described. Thus, as shown in Table III, there were four subsamples prepared and tested. Lignin was determined directly on small pieces of handsheets at Bathurst, but at Madison handsheets were first fluffed as specified in the TAPPI Standard.

The agreement of test values shown in Table III was considered satisfactory by the cooperating laboratories. What significance, if any, may be attached to the fact that handsheets made at Bathurst and tested at both laboratories had the higher chlorine number by about 0.5 in three out of four cases is not known. Lignin values determined at Bathurst were all slightly the higher, averaging 0.15 percentage point. This difference is significant at the 0.0005 level. This is probably due to a difference in technique—possibly in the extrac-

Table III. Values Obtained at Two Laboratories for the Chlorine Number and Lignin Content on Samples of a High-Yield Kraft Pulp No. 11

Samples	Chlorine number		Lignin[a], %	
	Bathurst[b]	F.P.L.[b]	Bathurst[b]	F.P.L.[b]
1. Slush pulp handsheeted at Bathurst		17.45	13.48	13.42
		17.35	13.65	13.42
Av.	17.0	17.40	13.57	13.42
2. Slush pulp handsheeted at Forest Products Laboratory		16.75	13.06	12.98
		17.05	13.29	12.94
				13.04
Av.	16.6	16.90	13.17	12.99
3. Slush pulp air-dried, reslushed, and handsheeted at Bathurst		16.65	13.36	13.20
		16.85	13.41	13.33
				13.44
Av.	17.2	16.75	13.39	13.32
4. Slush pulp air-dried at Bathurst, then reslushed and handsheeted at Forest Products Laboratory		16.80	13.30	13.13
		16.65	13.20	13.09
				13.07
Av.	16.7	16.73	13.25	13.10
Grand av.	16.9	16.95	13.35	13.21

[a] Lignin was determined on handsheets torn apart by hand.
[b] The laboratories are Bathurst Power & Paper Co., Ltd., Bathurst, N. B., and the U. S. Forest Products Laboratory, Madison, Wis.

tants used. However, no significant difference in precision at the 0.2 level was found between the two laboratories in the determination of the lignin contents of the samples. The standard deviation for Bathurst lignin data is 0.1086, and for the Madison data, 0.0715.

Since the correlation established within the limits of the present study is considered reliable, it is probably preferable to the one for high-yield kraft pulps published previously (*1*).

CONCLUSIONS

It was concluded that the relation of chlorine number to lignin content of the pulps tested was linear, the regression of chlorine number on lignin being:

$$\text{Chlorine number} = 1.2290 \cdot \text{per cent lignin} + 0.1851$$

Lignin content as a function of chlorine number is expressed as follows:

$$\text{Per cent lignin} = 0.8108 \cdot \text{chlorine number} - 0.1096$$

Tests of pulps before and after screening showed that the presence of moderate amounts of fiber bundles (shives) did not influence the chlorine-lignin relation.

From a limited examination of filtrates in the determination of lignin, it appeared unlikely that acid-soluble lignin was present.

In control testing, an experienced operator should be able to determine a chlorine number in about 30 min. The standard deviation for the determination within the limits of the present study was 0.1031. The method appears to be suitable for mill control purposes.

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Acknowledgment is made to the Bathurst Power & Paper Co., Ltd., especially to J. McK. Limerick for cooperation in the interlaboratory study and to the Container Corp. of America, the North Carolina Pulp Co., the St. Joe Paper Co., the St. Lawrence Corp. Ltd., and the Weyerhaeuser Timber Co. for supplying samples.

Received Oct. 8, 1954. Presented at the Eigth Alkaline Pulping Conference of the Technical Association of the Pulp and Paper Industry, Birmingham, Ala., Oct. 6–8, 1954.

Measurement of Retention of Resins in Paper

R. BHARGAVA, H. A. HOFFMAN and V. STANNETT

A simple extraction method for measuring the retention of phenol-formaldehyde and various thermoplastic resins in paper is described. The need for extracting the sheet in the wet form is demonstrated and the efficiency of the method is shown by measuring the resin content of sheets containing a known amount of resin. The results are shown in tabular form for two typical resins: (1) polyvinyl acetate and (2) phenolformaldehyde resin.

The growing use of resins of all types in combination with paper has led to a need for measurement of their retention during the process of addition. With saturation procedures the basis weight of the sheet before and after treatment can be used to gage the resin content with a fair degree of accuracy. However, when the resin is added by a beater addition process, a specific analytical technique needs to be used.

In many instances the resin contains an element which may be determined by standard analytical methods, examples being nitrogen in the case of melamine and urea resins and chlorine in the case of neoprene. This leads to a straightforward method for determining the resin content of the treated paper providing a blank determination may be carried out on an untreated sample. More recently a direct spectrographic method has been successfully used (*1*) for the determination of melamine resin in paper where the untreated paper need not be available.

However, there is widespread use of resins such as polyvinyl acetate, polyacrylate and phenol-formaldehyde resins, which contain no such easily determined elements. This paper describes a simple extraction procedure suitable for the determination of the retention of many resins of this type. The method is limited to cases where the sheet may be obtained before drying and the untreated pulp is available for a blank determination. However, it is of great value for experimental work and for pilot plant and production runs.

At first sight it would appear that any soluble resin could be quantitatively removed from the treated sheet by a simple solvent extraction. However, it was found that when the treated sheet has dried, part of the resin is held tenaciously by the sheet or otherwise becomes inextractable. Table I illustrates this difficulty for the case of polyvinyl acetate treated papers. Furthermore, many resins, in particular phenolic resins, "cure," i.e., crosslink during the drying process and become insoluble.

The following wet extraction procedure was devised which has been found to give satisfactory results with the following resins: polyvinyl acetate, polyethyl acrylate, polystyrene, various styrene copolymers and phenol-formaldehyde resins. Natural and synthetic rubbers have not been tried but could be estimated providing the latex particles are soluble in a suitable solvent.

METHOD

Polyvinyl Acetate and Similar Polymers

The wet resin-treated sheets are soaked and macerated in warm dioxane for 5 min. and then transferred quantitatively to a Jena glass filter grade C. The

R. Bhargava, H. A. Hoffman and V. Stannett, State University of New York College of Forestry, Syracuse, N. Y.

mixture is filtered with suction into a clean filter flask and washed with fresh dioxane. The pulp is dried and weighed and the filtrate and washings evaporated to dryness and the residue weighed. If inconveniently large volumes are involved, the filtrate may be made up to a known volume and an aliquot taken for the estimation.

Table I. Solvent Extraction of Dried Sheet (Polyvinyl Acetate Treated)

Sample no.	*Amount of resin added, g.*	*Method of resin addition*	*Method of extraction*	*Time of Extraction hr.*	*Condition of paper stock before extraction*	*Amount of residue extracted g.*	*Correction for pulp-blank g.*	*Corrected amount extracted g.*	*Added resin recovered, %*
1	0.4220	Saturation	Soxhlet with acetone	24	Dry Pieces of paper	0.3856	0.0004	0.3852	91.3
2	0.3811	Saturation	Soxhlet with acetone	24	Dry pieces of paper	0.3523	0.0004	0.3519	92.3
3	0.15	Beater addition	Soxhlet with acetone	24	Dry pieces of paper	0.0935	0.0013	0.0922	61.4
4	0.15	Beater addition	Soxhlet with acetone	48	Dry pieces of paper	0.1000	0.0015	0.0985	65.6
5	0.136	Beater addition	Soxhlet with acetone	10	Microground pulp	0.1164	0.0008	0.1156	85.0
6	0.143	Beater addition	Soxhlet with acetone	10	Microground pulp	0.1230	0.0012	0.1218	85.2
7	0.129	Beater addition	Soxhlet with acetone	24	Microground pulp	0.1184	0.0008	0.1176	91.2
8	0.137	Beater addition	Soxhlet with acetone	24	Microground pulp	0.1284	0.0013	0.1271	92.8

A blank determination is made on the pulp to correct for any soluble matter present. The two weighings, corrected by the blank, give directly the percentage of resin in the pulp.

Phenol-Formaldehyde Resins

The wet resin treated sheets are shaken with dimethyl formamide at room temperature for 3 hr. The mixture is then filtered and the pulp washed, dried, and weighed as before. The filtrate is evaporated to dryness and the residue weighed. A blank is run on an untreated sheet and the results corrected accordingly.

Table II. Wet Extraction Method (Polyvinyl Acetate Treated Sheets)

Amount of pulp, g.	*Resin added, g.*	*Residue extracted, g.*	*Resin extracted (corrected for blank)*	*Extraction, %*	*Solvent used*
2.3000	0.12	0.1173	0.1164	97	Acetone
2.8420	0.12	0.1192	0.1184	98.4	Acetone
2.3650	0.10	0.0979	0.0970	97	Acetone
2.9765	0.10	0.0995	0.0983	98.3	Acetone
2.6223	0.10	0.0980	0.0970	97.0	Acetone
2.8123	0.10	0.0984	0.0973	97.3	Acetone
2.1340	0.15	0.1502	0.1488	99.2	Dioxane
2.4102	0.10	0.0997	0.0983	98.3	Dioxane
2.3210	0.15	0.1480	0.1466	97.7	Dioxane
2.4102	0.15	0.1484	0.1470	98.0	Dioxane

Note: Resin precipitated by use of alum.

CHOICE OF SOLVENT

It is wise to check the solubility of the resin before carrying out the estimation although dioxane has been found suitable for all the thermoplastic resins so far investigated and all the phenolic resins studied have been found to be soluble in dimethyl formamide. The solvent chosen should be water miscible although this requirement can be overcome by washing the sheet with a little acetone before adding the chosen solvent and combining the acetone wash with the final extract. For convenience, a solvent which may be evaporated at a reasonable rate is preferable.

RESULTS

In order to check the accuracy of the method, sheets were prepared containing an exactly known amount of resin. These were prepared by a "beater addition" technique as saturated sheets are normally easier to extract even after drying as may be seen in Table I. The method used was to precipitate a known weight of resin on to a known weight of pulp by the addition of alum to pH 4.5. The "white water" was evaporated to dryness and the resin content corrected for any soluble portion not precipitated by the resin.

Table III. Wet Extraction Method (for Phenol-Formaldehyde Resin Treated Sheets)

Amount of pulp, g.	*Resin added, g.*	*Resin recovered, g.*	*Resin recovered, %*
1.215	0.0289	0.0290	100.0
1.203	0.0275	0.0281	100.2
1.211	0.0485	0.0478	98.6
1.209	0.0470	0.0458	97.6
1.216	0.1216	0.1190	97.9
1.212	0.1930	0.1830	95.0

The sheets were then analyzed for resin content using the wet method described above. The results are recorded in Tables II and III.

CONCLUSIONS

The results shown in Tables II and III show that a quantitative extraction of resin for paper can be obtained by the methods described. Many other flexible polymers have been satisfactorily estimated by this procedure. The method is limited to cases where the treated sheet is available before drying, i.e., in experimental work or directly from the paper machine before the drying section.

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We are grateful to Gordon Moulds for suggesting dimethyl formamide as a solvent and to National Starch Products, Inc., and Durez Plastics and Chemicals, Inc., for supporting this work.

ASSOCIATION NEWS AND EVENTS

Local Section Meetings

Maine-New Hampshire: June 24–25, 1955, Eastern Slope Inn, North Conway, N. H. Visit to the mill of the Brown Co., Berlin, N. H., "Paper Machine Operating Problems." The banquet speaker will be L. F. Whittemore, president of the Brown Co. Annual meeting.

Future National Meetings

Fourth Statistics Summer Course, Forest Products Laboratory, Madison, Wis., June 10–23, 1955.

Sixth Fundamental Research Conference, Institute of Paper Chemistry, Appleton, Wis., "Principles of Bleaching."

Second Mechanical Pulping Conference, Poland Spring House, Poland Spring, Me., Sept. 15–17, 1955. Visit to mill of Great Northern Paper Co., Millinocket, Me.

Fifth Testing Conference, Sheraton-Kimball Hotel, Springfield, Mass., Sept. 28–30, 1955.

Fifth Corrugated Containers Conference, Morrison Hotel, Chicago, Ill., Oct. 5–7, 1955.

Ninth Alkaline Pulping Conference, Hotel Patten, Chattanooga, Tenn., Oct. 19–21, 1955. Visit to mill of Bowaters Southern Paper Corp., Calhoun, Tenn.

Tenth Engineering Conference, Rice Hotel, Houston, Tex. Visits to mills of Champion Paper & Fibre Co., Pasadena, Tex., East Texas Pulp & Paper Co., Evadale, Tex., and Southland Paper Mills, Lufkin, Tex.

Tenth Plastics-Paper Conference, Brooklyn Law School Brooklyn, N. Y., Nov. 14–15, 1955.

Forty-First Annual Meeting, Commodore Hotel, New York, N. Y., Feb. 20–23, 1956.

Reference Pulp Program

On page 138A of the April, 1955, issue of *Tappi*, Frank Caskey, chairman of the TAPPI Pulp Testing Committee, outlined a plan whereby samples of bleached sulphite pulp would be made available to individuals or companies who might wish to check their testing methods and apparatus.

Interested persons were requested to write to the Secretary of the Association if they would be interested in obtaining such samples. It is the opinion of the Pulp Testing Committee that considerable benefit can be received by such a reference pulp program. When the plan was submitted to TAPPI members at the 1954 Testing Conference held at Dayton, Ohio, it appeared to be well received.

Since it will be necessary to make arrangements for obtaining the pulp supply and reducing it to convenient samples, it is very important that members of the Association advise the Secretary that they will wish to obtain samples. It will not be possible to proceed with the service unless there is tangible evidence that it is wanted.

Ninth Alkaline Pulping Conference

Preliminary arrangements have been made for the Ninth Alkaline Pulping Conference to be held at the Patten Hotel, Chattanooga, Tenn., on Oct. 19–21, 1955.

At a meeting held in Calhoun, Tenn., on April 12, George Koons of the Bowaters Southern Paper Co. was appointed chairman of the Local Arrangements Committee. The meeting will be featured by a visit to the very modern mill of the Bowaters Southern Paper Co. where alkaline pulping, mechanical pulping, and newsprint manufacturing operations will be observed.

David Wetherhorn of the Southern Paperboard Corp., Port Wentworth, Ga., chairman of the technical program committee, has announced that Malcolm B. Pineo, Brunswick Pulp & Paper Co., Brunswick, Ga., chairman of the Alkaline Pulping Committee, has appointed the following moderators of the technical sessions dealing with kraft pulping: T. T. Collins, Hudson Pulp & Paper Co., Palatka, Fla.; J. J. Goss, Gaylord Container Corp., Bogalusa, La.; and Vernon Woodside, Olin-Mathieson Chemical Corp., New Orleans, La.

Although the technical program has not taken full form the following subjects appear to be definite parts of the program:

(1) Effect of Old Wood in the Kraft Pulping Process; (2) Specific Heat of Black Liquid; (3) The New Foxboro Magnetic Flow Meter; and (4) The Kamyr Continuous Cooking Process.

The fourth technical session is being arranged by the Semichemical Pulping Committee.

Tenth Engineering Conference

Preliminary plans are being made to hold the Tenth Engineering Conference at the Rice Hotel, Houston, Tex.

One of the features of the meeting will be a visit to the mill of the Champion Paper & Fibre Co., at Pasadena, Tex. The mill is a highly integrated plant which produces its own caustic and chlorine. Its daily production includes 330 tons of paper, 110 tons of paperboard, and 525 tons of pulp.

The major airlines serving Houston are Eastern, Braniff, Continental, American, Delta-C & S, Pioneer and Trans Texas. Through plane service from the West Coast is available through TWA-Braniff, and American-Continental interchanges. From the East, Eastern Airlines runs direct nonstop flights from New York and Washington. Other points are served on a local basis.

The major rail lines are Santa Fe, Southern Pacific, Missouri Pacific, Rock Island, Fort Worth & Denver, and Missouri-Texas-Kansas lines. Through pullman service is available from New York and Washington via Pennsylvania-Missouri Pacific route, and from Washington via Louisville and Nashville and Nashville-Southern Pacific interchange.

Services that Enrich

Clyde Williams, president and director of the Battelle Memorial Institute, Columbus, Ohio, appreciates the valuable contributions of technical societies. In the March issue of the *Battelle Technical Review* he writes:

"Technical societies are so much a part of our technological culture that they are sometimes taken for granted. People know that technical societies perform worth-while services, yet the public at large has but a vague idea of what these services are. Even scientists and engineers may have limited perspective on the roles of technical societies to further scientific and industrial progress.

The main objective of the technical society is usually to promote the field of science, technology, or engineering with

which it is associated. This is accomplished through the sponsorship of publications, meetings, lectures, symposia, expositions, awards, and group attack on technical problems. Other objectives are the furthering of recognition of the professional status of members, the encouragement of industry in the area of technical endeavor, and the formulation of engineering standards.

In pursuing their various objectives, technical societies perform many notable services that enrich science, industry, and the general public welfare. They are valuable adjuncts to our universities and technical schools in educating young people in science and engineering. Through their publications, symposia, and lectures, they also keep professional scientists and engineers informed and up to date in their technical knowledge. Thus, they are, in a sense, universities in which their members matriculate for a lifetime of study and instruction.

Technical societies, by providing platforms on which ideas are discussed and weighed, are safeguards for truth and scientific integrity. They keep technical people from veering off the path, and they are bulwarks against external threats to scientific thinking and procedure. At the same time, technical organizations serve as focal points around which schools of new thought can rally and find expression. These schools of thought, just as those of artists and musicians, stimulate creativity.

Technical societies encourage a fraternal type of spirit among members. This feeling of kinship facilitates the interchange of ideas and provides the underlying foundation for fruitful friendships and constructive competition. Unanimity in the devotion of technical people to great public causes is frequently solidified at the annual meetings of technical societies.

And, of course, technical societies are a boon to research. Their mechanisms for communication are the traditional mechanisms used by research people for the interchange of knowledge. Their publications are records of research experience, effort, and thought. The abstract services, bibliographies, and indexes they provide are tools used in nearly all creative investigations. The studies sponsored directly by technical society committees fill important gaps in knowledge and hasten the application of science to the solution of human problems. Without these services, research could not possibly have made the great contribution to human welfare it has in recent decades."

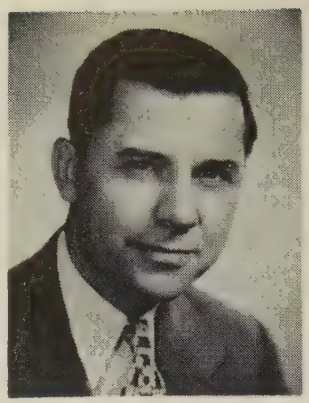
Fifth Fundamental Research Conference

Plans for the 1955 Fall Symposium to be held at The Institute of Paper Chemistry, Sept. 15–17, on the Theoretical Aspects of Bleaching are moving along in good shape. The chairman of the Symposium, J. R. Salvesen of Marathon Corp., reports that the list of speakers already selected includes Georg Jayme, Institute for Cellulose Chemistry, Darmstadt; F. Loschbrandt, Norwegian Pulp and Paper Research Institute, Skoyen, Norway; Charlie Gustafsson of the Central Laboratories of Helsinki, Finland; H. Leugering, Zellstoff. Waldhof, Mannheim, Germany; and C. C. Purves, McGill University, Montreal. The program as planned will include two days of formal papers and one day of discussion and summary. Registration will be limited to 200.

Sixth Testing Conference

The Sixth TAPPI Testing Conference will be held at Springfield, Mass., Sept. 28 to 30, 1955. Featured at the conference will be visits to the Strathmore Paper Co. mill at West Springfield, and the Tecnifax Corp. mill at Holyoke.

Strathmore Paper Co. was one of the first in the paper industry to realize the importance of scientific research. They have maintained a fellowship at Mellon Institute for about 40 years. Their continuance among those in the forefront of the fine paper manufacturers can be traced in part to their continuing interest in research, development, and control.



P. W. Bartholomew, Minnesota & Ontario Paper Co., General Chairman, Sixth Testing Conference

The Tecnifax Corp. are large manufacturers of diazotype reproduction papers. In their mill at Holyoke, they manufacture the base stocks for these papers. Here, also, these stocks are coated (actually surface impregnated). Visits to these two outstanding mills will be available and important to those attending the Testing Conference.

The meetings for the Sixth TAPPI Testing Conference will be held at the Sheraton Kimball Hotel in Springfield. In the hotel will also be held an exhibit of newer testing equipment as an adjunct to the conference.

The paper converter, as well as the paper manufacturer, should find much of interest in the following list of technical papers now scheduled for conference presentation.

"A Study of Dirt in Pulp Determination (round robin)," Frank E. Caskey, Chairman, Pulp Testing Committee

"Water Vapor Permeability of Sheet Material (round robin)," T. E. Dobbins, Chairman, Packaging Materials Testing Committee

"Talk on Routine Control Methods," E. E. Stephenson, Chairman, Routine Control Methods Committee

"Proposed Greaseproofing Test," Lois Hans, Quartermaster Research & Development Center, U. S. Army, Natick, Mass.

"Proposed Waterproofing Test," Lois Hans

"Significance of Heat-Seal Strength Tests," Lois Hans

"Comparative Tests of the Bekk and Sheffield Smoothness Testers," R. Lashof, National Bureau of Standards, Washington, D. C.

"The Determination of Starch in Paper," J. L. Harvey and B. W. Forsche, National Bureau of Standards, Washington, D. C.

"Moisture Gain and Loss in Kraft Paper and Board," J. S. Moore, Union Bag & Paper Corp., Savannah, Ga.

"Determination of the Permeability Constant of Gases and Vapors by High Vacuum Technique," John Meyer, V. T. Stannett, and M. Szwarc, College of Forestry, State University of New York, Syracuse, N. Y.

The Testing Conference has always been a "working" conference. Much of the work of the conference has been done in the meetings of the standing committees which take place the first day of the conference. The agenda of the committee meetings and the titles of additional technical papers will be announced shortly.

Membership in the Testing Division or in TAPPI itself is not a necessary requirement for conference attendance. All interested are invited to attend and to participate in conference activities. Those who wish to participate in any conference committee activity, are urged to contact the chairman of the committee of their choice. He will welcome assistance.

J. P. Casey, General Chairman, Testing Division, Director of Technical Service, A. E. Staley Mfg. Co., Decatur, Ill.

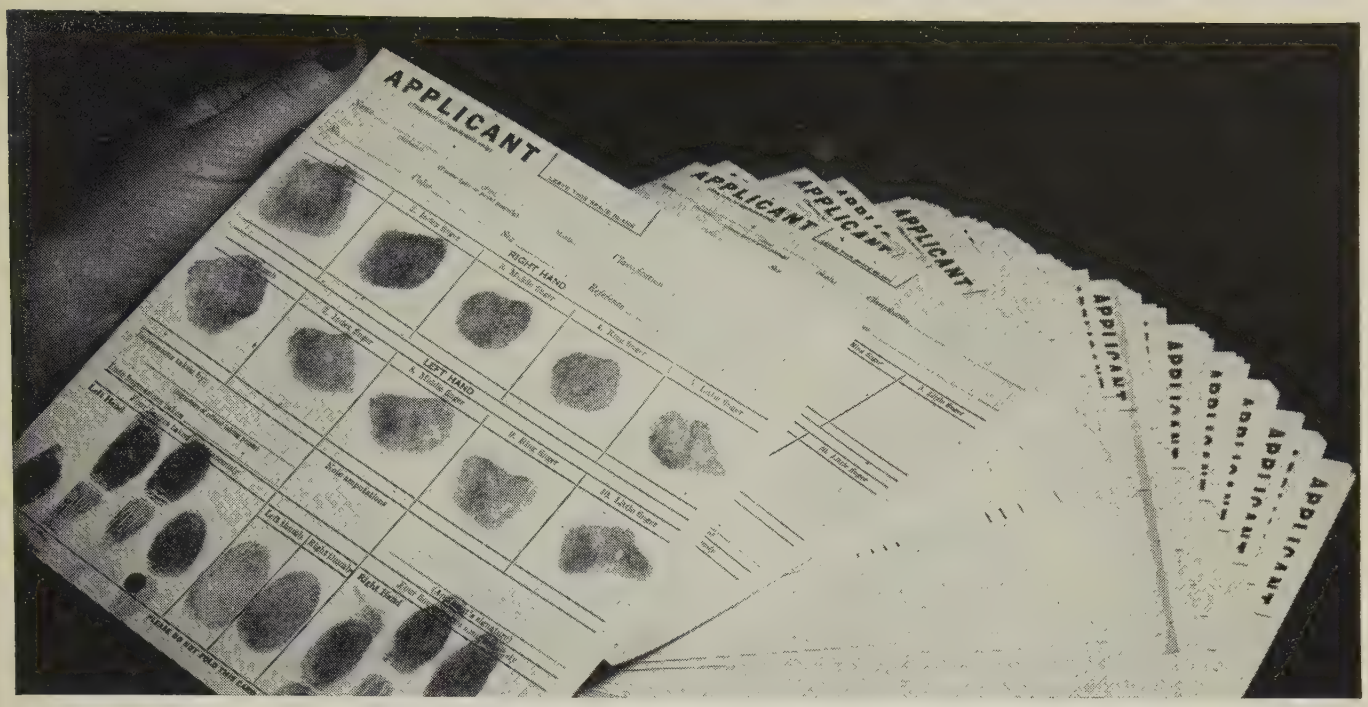
P. W. Bartholomew, General Chairman, Sixth TAPPI Testing Conference Committee, Technical Director, International Falls Mill, Minnesota and Ontario Paper Co., International Falls, Minn.

R. W. Ramsdell, Chairman, Local Arrangements Committee, Technical Sales, Hercules Powder Co., Springfield, Mass.

R. H. Simmons, Chairman, Program Committee, Chemist, U. S. Government Printing Office, Washington, D. C.

Wm. Schoenberg, Chairman, Publicity and Exhibition Committees, Lord & Schoenberg, Cleveland, Ohio

C. Lester Reece, Chairman, Registration Committee, Technical Paper Sales, Westfield River Paper Co., Inc., Russell, Mass.



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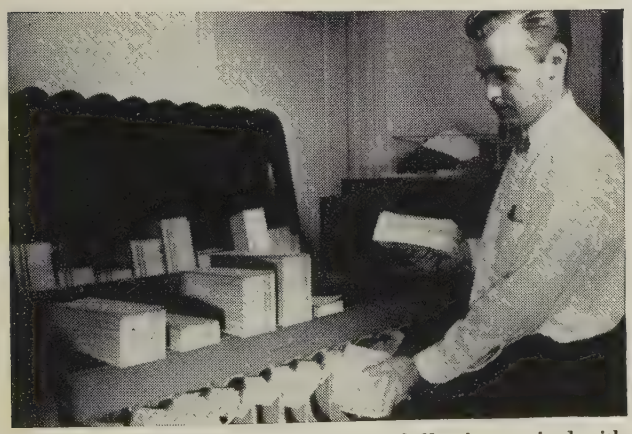

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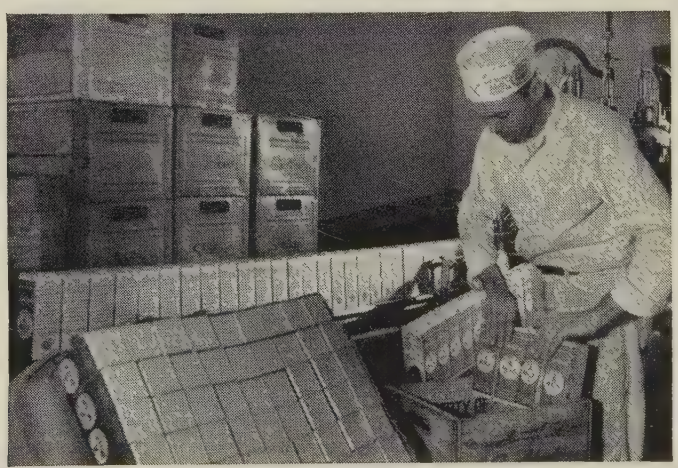

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Jean H. Achard-Picard, Engineer, Achard-Picard-Remy & Co., Paris, France.

Frank F. Ahrens, Plant Engineer, Champion Paper & Fibre Co., Pasadena, Tex. Attended Iowa State College.

Gordon P. Andrew, Chief Chemist, Technical Sales and Demonstration, Original Bradford Soap Works, Inc., W. Warwick, R. I., a 1925 graduate of Bradford Durfee Technical Institute.

Robert F. Avery, Pulp Technologist, American Viscose Corp., Marcus Hook, Pa., a 1953 graduate of New York State College of Forestry.

Sylvester W. Baird, Plant Superintendent, Merit Container Corp., Wassaic, N. Y.

Edward W. Beauvais, Manager, Technical Dept., American Box Board Co., Filer City, Mich., a 1934 graduate of Tri-State College.

Edwin Behn, General Manager, Erwin Behn Verpackungsbedarf G.m.b.H., Krefeld, Germany. Attended Hamburg College.

Max W. Benjamin, President, Boddy, Benjamin & Woodhouse, Inc., Detroit, Mich., a 1926 graduate of the University of Michigan.

Leo J. Bernadin, Graduate Student, Institute of Paper Chemistry, Appleton, Wis., a 1952 graduate of Tufts College.

Fernando R. Bertolini, Student, Vienna, Austria.

Gerard Bizot, Director, Papeteries de Condat, Paris, France. Attended the University of Paris.

Harry E. Bland, Designer, Black-Clawson Co., Shartle Bros. Div., Middletown, Ohio. Attended State Teachers College, Oswego, N. Y.

Saul Bollt, Production Supervisor, Merit Container Corp., Wassaic, N. Y., a 1937 graduate of Bard College, Columbia University.

Samuel T. Broaddus, Supervisor, S. D. Warren Co., Westbrook, Me., a 1947 graduate of Dickinson College.

Howard B. Brown, Resident Engineer, National Council for Stream Improvement, New York, N. Y., a 1950 graduate of Purdue University.

Howard F. Brown, Vice-President in charge of Manufacturing, Lockport Felt Co., Newfane, N. Y.

Maurice M. Brundige, Supervisor of Experimental Coater, West Virginia Pulp & Paper Co., Luke, Me., a 1938 graduate of Southwestern University.

Ralph L. Bullock, Chemist, Drycor Felt Co., Staffordville, Conn., a 1943 graduate of Lowell Technological Institute.

Charles W. Cairns, Coating Salesman, The Dow Chemical Co., Midland, Mich., a 1948 graduate of Coe College.

Robert W. Cairns, Assistant Director of Research, Hercules Powder Co., Wilmington, Del. Attended the University of California and Oberlin College, with Ph.D. degree from Johns Hopkins University in 1932.

Carlyle G. Caldwell, Assistant Vice-President, National Starch Products, Inc., New York, N. Y., a 1940 graduate of Iowa State College with a Ph.D. degree.

Joseph P. Carey, Jr., Research Chemist, Dennison Mfg. Co., Framingham, Mass., a 1937 graduate of Harvard University.

Casimir C. Chesney, Sales Technician, Phenix Foods Co., Div. of Kraft Co., Chicago, Ill., a 1950 graduate of Chicago Technical College.

Jan Chrystman, Director of Development and Production, Norman Wade Co. Ltd., Toronto, Ont., Canada, a 1941 graduate of the University of Sheffield, England.

Harold W. Cobb, Sales Engineer, Bart Mfg. Corp., Belleville, N. J., a 1937 graduate of Amherst College.

George A. Cuff, Mill Superintendent, Robert Gair Co., Inc., Uncasville, Conn.

Stuart L. Dalheim, Student, State University of New York, College of Forestry, Syracuse, N. Y.

J. Lawler Davis, Technical Salesman, American Cyanamid Co., New York, N. Y., a 1950 graduate of the University of Toronto.

Arthur C. Dreshfield, Jr., Student, Institute of Paper Chemistry, Appleton, Wis., a 1951 graduate of the University of Illinois.

Douglas Duncan, Technical Director, Missisquoi Corp., Sheldon, Vt.

George N. Dutcher, Vice-President and Treasurer, Stora Kopparberg Corp., New York, N. Y.

John T. Flythe, Jr., Mechanical Engineer, Miller Hopft, Inc., Richmond, Va., a 1940 graduate of the University of Virginia.

Frank F. Ford, Construction and Plant Engineer, Canadian Glassine Co. Ltd., Quebec, P. Q., Canada, a 1941 graduate of the University of Michigan.

Samuel Goldstein, President and General Manager, Merit Container Corp., New York, N. Y.

Serge N. Gorbatsevich, Graduate Student, New York State College of Forestry, Syracuse, N. Y.

Willard H. Graham, Quality Control Supervisor, Johns-Manville Products Corp., Natchez, Miss., a 1939 graduate of Michigan State College.

Oskar Hentschel, General Superintendent, Celanese Mexicana S.A., Celulosa Div., Tamaulipas, Mexico, a 1950 graduate of the University of Puebla.

Eugenio U. Hermosilla, Manager of Manufacturing, Spanish Artificial Textile Fibers Co., Burgos, Spain, a 1933 graduate of the University of Larapoza.

David S. Hollingsworth, Technical Sales, Hercules Powder Co., Wilmington, Del., a 1948 graduate of Lehigh University.

John R. Holmgren, Development Engineer, Buckeye Cotton Oil Co., Memphis, Tenn., a 1942 graduate of Michigan Technical College.

Tsuneo Horiko, Head, Research Dept., Nippon Soda Co. Ltd., Tokyo, Japan, a 1938 graduate of Yonezawa Technical College.

Elmer R. Hunting, Jr., Divisional Chemist, Fraser Paper Ltd., Madawaska, Me., a 1942 graduate of Northeastern University.

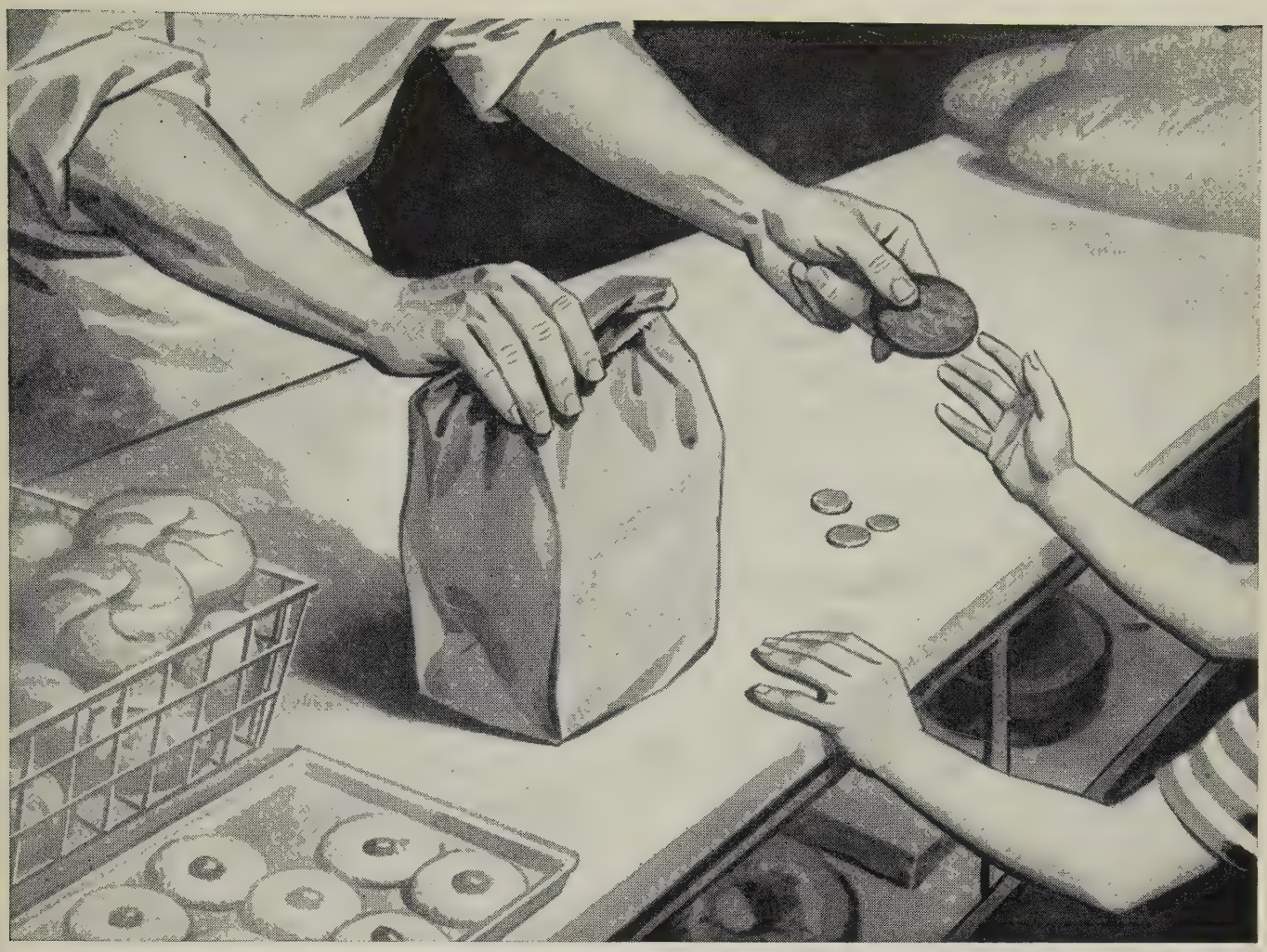
Harold A. Jacoby, Sales Engineer, Conkey Equipment Div., Chicago Bridge & Iron Co., New York, N. Y., a 1938 graduate of the University of Alabama.

Keith B. Johnson, Student, State University of New York, College of Forestry, Syracuse, N. Y.

Roy E. Johnson, Plant Engineer, Albemarle Paper Co., Richmond, Va., a 1940 graduate of Virginia Polytechnic Institute.

Carlton S. Joyce, Senior Research Assistant, Pulp and Paper Research Institute of Canada, Montreal, P. Q., Canada, a 1951 graduate of Sir George Williams College.

Harry E. Kaley, Project Engineer, Armstrong Cork Co.,



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Chloroform • Methylene Chloride • Methyl Chloride • Carbon Tetrachloride

Lancaster, Pa., a 1918 graduate of Pennsylvania State University.

Keiji Kamei, Chief Librarian, Tokyo Institute of Technology, Tokyo, Japan, a 1950 graduate of Hiroshima University.

Cornelis N. Kaper, Managing Director, Fasting-Jonk N.V., The Hague, Holland, a 1939 graduate of Alkmaar College.

Edwin A. Kass, Sanitary Engineer, Gibbs & Hill, Inc., New York, N. Y., a 1937 graduate of Massachusetts Institute of Technology.

Joseph D. Kehoe, Chemist, Morningstar, Nicol, Inc., Hawthorne, N. J., a graduate of Stevens Institute of Technology.

William J. Kolson, Assistant Plant Superintendent, Merit Container Corp., Wassaic, N. Y.

Morton W. Leeds, Section Head, Air Reduction Co., Murray Hill, N. J., a 1944 graduate of Polytechnic Institute of Brooklyn with a Ph.D. degree.

Francis R. Marchette, Chemist, Paper Sec., Technical Service Laboratories, Titanium Pigment Corp., New York, N. Y., a 1950 graduate of Brown University.

Jadwiga Marchlewska-Szrajerowa, Director, Pulp and Paper Research Institute, Lodz, Poland, a graduate of the Universities of Poznan and Vienna with a Ph.D. degree.

Yuichiro Maruse, Director of Manufacturing, Japan Monopoly Corp., Shinagawa-ku, Tokyo, Japan, a 1933 graduate of Tokyo Imperial University.

Jean Mater, Trainee, Oregon Forest Products Laboratory, Corvallis, Ore., a 1940 graduate of Columbia University.

William M. Newton, Methods Engineer, The Mead Corp., Chillicothe, Ohio, a 1950 graduate of Rensselaer Polytechnic Institute.

Elce P. Nuttall, Free-Lance Writer, Trade Journal Publisher to Paper and Board Industry, Flushing, N. Y.

Per-Erik Ohls, Technical Manager, United Paper Mills Ltd., Kaipola, Finland, a 1947 graduate of Helsinki Technical College.

Theodore F. Payne, Jr., Management Trainee, Lowe Paper Co., Ridgefield, N. J., a 1954 graduate of the Fairleigh Dickinson College.

Irwin A. Pearl, Research Associate, The Institute of Paper Chemistry, Appleton, Wis., a 1934 graduate of the University of Washington with a Ph.D. degree in 1937.

William J. Petter, Partner, Ronningen-Petter Co., Paper Mill Machinery, Vicksburg, Mich., a 1950 graduate of Western Michigan College.

Leo N. Poccia, Technical Director, Arvey Corp., Fibre Forming Div., Olean, N. Y., a 1942 graduate of Clarkson College.

O. Lara Poire, Mill Superintendent, Cia, Papelera "El Fenix" S.A., Mexico, D. F., Mexico, a 1942 graduate of the National University of Mexico.

Edward Race, Director, Research and Development, Scapa Dryers Ltd., Blackburn, Lancs., England, a 1933 graduate of the University of Durham with a Ph.D. degree.

Ferdinand Reiff, Director, Research Laboratory, Zellstofffabrik Waldhof, Mannheim-Waldhof, Germany.

Josef Reingruber, Superintendent, Cia. Santista de Paper, São Paulo, Brazil, a 1934 graduate of the University of Vienna.

Frederich H. Richter, Assistant Superintendent, Steam and Power Dept., Bowaters Southern Paper Corp., Calhoun, Tenn., a 1937 graduate of Alabama Polytechnic Institute.

Charles C. Rippberger, Shift Superintendent, Rayonier, Inc., Jesup, Ga., a 1939 graduate of Georgia School of Technology.

Alfred G. Russell, Sales Engineer, Frank W. Egan & Co., Somerville, N. J., a 1950 graduate of Rutgers University.

Ramon A. St. Onge, Field Engineer, Beckman Instruments, Inc., Fullerton, Calif., a 1952 graduate of the University of Detroit.

Olof Samuelson, Professor, Chalmers Technical University, Goteberg, Sweden.

Philip C. Sangster, Jr., Microbiologist, S. D. Warren Co., Cumberland Mills, Me., a 1950 graduate of J. B. Stetson University.

Bertram Sayer, Salesman, Rohm & Haas Co., Philadelphia, Pa., a 1951 graduate of Syracuse University.

Alan N. Schmidt, Technical Assistant, General Purchasing Dept., Paper Container Supplies Div., American Can Co., New York, N. Y., a 1950 graduate of Pennsylvania State University.

Herbert W. Schnabel, Manager of Development, Armour & Co., Alliance, Ohio, a 1948 graduate of Illinois Institute of Technology.

George O. Schroeder, Chemist, Research and Development Center, American Can Co., Barrington, Ill., a 1948 graduate of Fordham University.

Filippo Sertorio, General Manager, Cartiera Italiana S.p.A., Torino, Italy.

Frank W. Showalter, Engineer, The American Envelope Co., Moraine Paper Co. Div., West Carrollton, Ohio.

George J. Simpson, Area Chemical Engineer, Riegel Carolina Corp., Acme, N. C., a 1954 graduate of Clemson College.

Lawrence J. Slentz, Pulping Assistant, Central Laboratory, St. Regis Paper Co., Deferiet, N. Y., a 1952 graduate of New York State College of Forestry.

Hiroshi Sobue, Professor of Applied Chemistry, Faculty of Engineering, Tokyo University, Tokyo, Japan, a 1941 graduate of Tokyo University with a D.Sc. degree.

Jules Soucy, Manager, F. F. Soucy, Inc., Cte Temiscouata, P. Q., Canada, a 1950 graduate of the University of Montreal.

Chester U. Stevens, Technical Director, The Eaton-Dikeman Co., Mt. Holly Springs, a 1933 graduate of Harvard University

Leo J. Stuckens, Technical Director, American Photocopy Equipment Co., Chicago, Ill., a 1924 graduate of the University of Ghent, Belgium.

Richard W. Swinehart, Director, Cellulose and Plastic Laboratory, The Dow Chemical Co., Midland, Mich., a 1931 graduate of Michigan College of Mining and Technology.

Herbert O. Teeple, Corrosion Engineer, International Nickel Co., Inc., New York, N. Y., a 1937 graduate of the University of Michigan.

Tage Thomasson, President, AB Klippans Finpappersbruk, Klippan, Sweden, a 1915 graduate of Kungl. Technical University.

Leonard J. Timmer, Assistant Chemist, Michigan Paper Co., Plainwell, Mich., a 1955 graduate of Western Michigan College.

Richard B. Valley, Chemical Engineer, Eastman Kodak Co., Rochester, N. Y., a 1950 graduate of Rensselaer Polytechnic Institute.

Luis J. S. Villa, Chemical Engineer, Mexican Institute of Technological Research, Mexico, D. F., Mexico, a 1952 graduate of Berzelius College of Engineering.

George P. Vincent, Director of Government Services, Olin-Mathieson Chemical Corp., Baltimore, Md., a 1923 graduate of Hiram College with a Ph.D. degree from Cornell University in 1927.

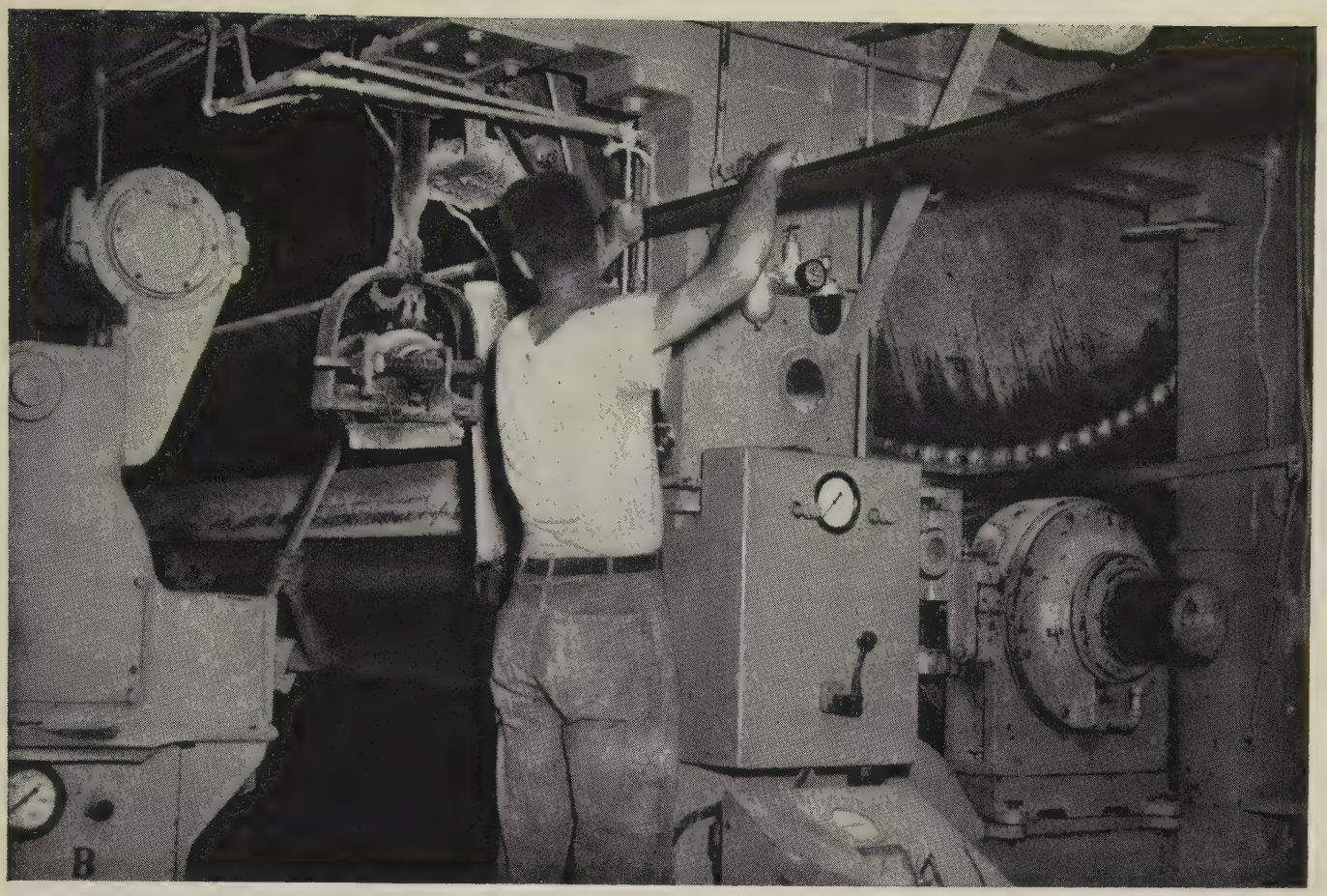
Luigi Viscogliosi, Owner and Manager, Feltrificio sul Liri, Isola del Liri, (Frosinone), Italy, a 1942 graduate of the University of Rome.

Elton L. Von Eschen, Laboratory Manager, Continental Baking Co., Jamaica, N. Y., a 1923 graduate of Williamette University.

Elliott L. Weinberg, Assistant Development Superintendent, Metal & Thermit Corp., Rahway, N. J., a 1947 graduate of the University of Illinois.

Douglas P. Whiting, Technical Service Representative, Coatings, The Dow Chemical Co., of Canada Ltd., Sarnia, Ont., Canada, a 1947 graduate of McGill University.

Earl Robert Zuehlke, Assistant Chief Engineer in charge of Hydraulics, Shartle Bros. Machine Div., Black-Clawson Co., Middletown, Ohio.



No bolts, no clamps. Doctor blades on this dryer are held in place by spring tension, can be changed quickly and with minimum loss of production. Makers of the blades, LODDING ENGINEERING CORP., Worcester, Mass., recommend "K" Monel because of its excellent resistance to corrosion, abrasion and wear.

Why you don't have to do this very often —when you use blades of "K" Monel

The paper on this Yankee dryer is running at 1400 feet a minute.

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But blades like these don't have to be changed often. They're made of "K"® Monel. They run 2 to 5 hours between regrinds, depending on the paper you're making. *And they last lots longer than most blades.*

Why? Because "K" Monel is an extra-strong, extra-hard nickel alloy. It has excellent resistance to wear and corrosion. Stands up on the really tough jobs.

For creping heavy paper and specialties, for use against dryer and flaker rolls, or hard rubber covered rolls, "K" Monel blades keep production up, hold costs down. And no wonder! *Their surfaces stay smooth, and wear uniformly. They leave your rolls clean and unscored. Prevent fiber buildup. End scratching.*

Put "K" Monel at the top of your list for corrosion-resisting, long-wearing doctor blades. "K" Monel is one of a family of long-life alloys which include Monel and Inconel.

"K" Monel doctor blades are available from the LODDING ENGINEERING CORP., Worcester, Mass. The firm specializes in doctor blades and holders. *Write them — Dept. K — for more information.* And, of course, write *us* any time you need help in picking the right metal for a corrosive job in your pulp or paper mill.

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William R. Zuhlke, Plant Engineer, Merit Container Corp., Wassaic, N. Y., a 1923 graduate of the University of Berlin, Germany.

TAPPI Notes

Donald M. Black of the Monsanto Chemical Co. has been transferred from Everett, Mass., to the Plastics Division, Springfield, Mass.

Joseph C. Brown of the Weyerhaeuser Timber Co. has been transferred from Springfield, Ore., to Longview, Wash., as Assistant Mill Manager of the Pulp Division.

James S. Brown of the Scott Paper Co. has been transferred from Marinette, Wis., to Detroit, Mich., as Production Manager.

Ian M. Chandler, formerly Chemical Engineer of the Brown Co., is now with Provincial Paper Ltd., Thorold, Ont., Canada

Warren J. Current, formerly of the Champion Paper & Fibre Co., is now Engineer for the H. K. Ferguson Co., New York, N. Y.

Roger C. Derby, trainee with the Champion Paper & Fibre Co., has been transferred from Pasadena, Tex., to Hamilton, Ohio.

Arthur L. DeSpain, formerly with Parsons & Whittemore Co., is now Sales and Design Engineer for the Kraft Equipment Co., Savannah, Ga.

J. Edward Doyle, Chemist for the St. Regis Paper Co., has been transferred from Deferiet, N. Y., to Pensacola, Fla.

H. O. Ehrisman is now General Sales Manager for the Foxboro Co., Foxboro, Mass.

Bruce P. Ellen is now Pulp and Power Superintendent for the Southern Paper Co., Port Wentworth, Ga.

John K. Ferguson is now Assistant Vice-President of the St. Regis Paper Co., New York, N. Y.

John F. Frisch, formerly of the Canadian Pulp and Paper Association, Technical Section is now Design Engineer for British Columbia Forest Products Ltd., Vancouver, B. C., Canada.

Arnold Ginsburg is now Vice-President and Director of the National Container Corp., Long Island City, N. Y.

Gordon J. Gill, formerly of the Solvay Process Co., is now Salesman for Penick & Ford Ltd., Inc., Cedar Rapids, Iowa.

Frederick W. Goetz, formerly of the Mead Corp., is now in charge of Research and Development for the Crowell-Collier Publishing Co., Springfield, Ohio.

Parker W. Gray, is now Technical Superintendent of the Long Lac Pulp & Paper Co., Terrace Bay, Ont., Canada.

Paul Hain is now Group Leader in the Paper Finishing Research and Development Division of the Champion Paper & Fibre Co., Hamilton, Ohio.

Kenneth B. Hallas, formerly student at Lowell Technological Institute is now Quality Engineer for the Dixie Cup Co., Easton, Pa.

James J. Harrison is now General Superintendent of the Michigan Carton Co., Battle Creek, Mich.

Raymond S. Hart of Hart Moisture Meters has moved his office from New York City to Babylon, N. Y.

Frederick P. Heil is now Supervisor of Felt Design and Finishing for the Lockport Felt Co., Newfane, N. Y.

George B. Hills, Jr., formerly of Powell River Co. Ltd., is now Executive Vice-President in Charge of Operations for Martin Paper Products Ltd., Winnipeg, Man., Canada.

Richard A. Hoover, formerly of the West Virginia Pulp & Paper Co., is now assistant to the finishing superintendent of the Hollingsworth & Whitney Div., Scott Paper Co., Waterville, Me.

Chuan-fa Hung, formerly student at the University of Maine, is now Chemist for the Nashua Corp., Nashua, N. H.

James M. Jopp, formerly of the Brown Corp., is now Director of Engineering for the Columbia Cellulose Co., Vancouver, B. C., Canada.

F. W. Kohler is now President of the Kohler System Co., Chicago, Ill.

Richard W. Loheed, formerly of Dairypak, Inc., is now Consulting Engineer with Loheed & Co., North Middleboro, Mass.

Richard M. Ludwig, Assistant Project Engineer for the Rust Engineering Co., has been transferred from Birmingham, Ala., to Pittsburgh, Pa.

James R. Lyon, formerly of Atlas Boxmakers, Inc., is now Research Director for Alton Box Board Co., Alton, Ill.

A. Harold Martin, formerly of Falls Paper & Power Co., is now Technical Director of the Marinette Paper Division, Scott Paper Co., Marinette, Wis.

Justin H. McCarthy, formerly chief engineer is now Vice-President of the St. Regis Paper Co., Jacksonville, Fla.

John A. McDermott is now Supervisor of Paper Mills for the St. Regis Paper Co., Jacksonville, Fla.

George D. M. Teague, formerly with Cia. Ind. de Papal Piraley, is now with Brown & Williamson Tobacco Corp., Louisville, Ky.

Vincent J. Mohan, formerly of the General Printing Ink Co., is now Research Chemist for Bensing Bros. & Deeney Sales Co., Philadelphia, Pa.

Lamar M. Murray is now President of the Kraft Equipment Co., Savannah, Ga.

Lewis G. Neubauer, formerly of the New Zealand Dominion Laboratory, is now Control Superintendent of the Tasman Pulp & Paper Co. Ltd., Kawerau, New Zealand.

Ralph F. Patterson is now Director of Planning and Research for the Powell River Co. Ltd., Vancouver, B. C., Canada.

Wesley L. Pearl, Project Engineer for the General Electric Co., has been transferred from Richland, Wash., to Schenectady, N. Y.

Rohe V. Pennington, formerly of the National Container Corp., is now Engineer with Condi Engineering Corp., Pittsfield, Mass.

Roderick A. Perkins, formerly of the Marinette Paper Co., is now Assistant Technical Director of the Oregon Pulp & Paper Co., Salem, Ore.

H. M. Pier is now Special Assistant to the Chairman of the Board of Research—Cottrell, Inc., New York, N. Y.

Walter B. Roberson is now Associate Director of Research for the Hudson Pulp & Paper Co., Palatka, Fla.

Lewis Simon, formerly of the Indian Forest Research Institute, is now Superintending Engineer of the Orient Paper Mills Ltd., Brajrajnagar, E. R. Dist. Sambalpur, India.

Samuel C. Slifkin is now Technical Consultant for Products Research & Development Co., Milwaukee, Wis.

Lester J. Smith is now General Superintendent of northern New York paper mills of the St. Regis Paper Co., Deferiet, N. Y.

Clyde W. Steele, formerly of the Combined Locks Paper Co., is now Technical Coating Superintendent of the Champion Paper & Fibre Co., Pasadena, Tex.

Henry R. Stevens, formerly of the Flintkote Co., is now Quality Control Supervisor for the Philip Carey Mfg. Co., Cincinnati, Ohio.

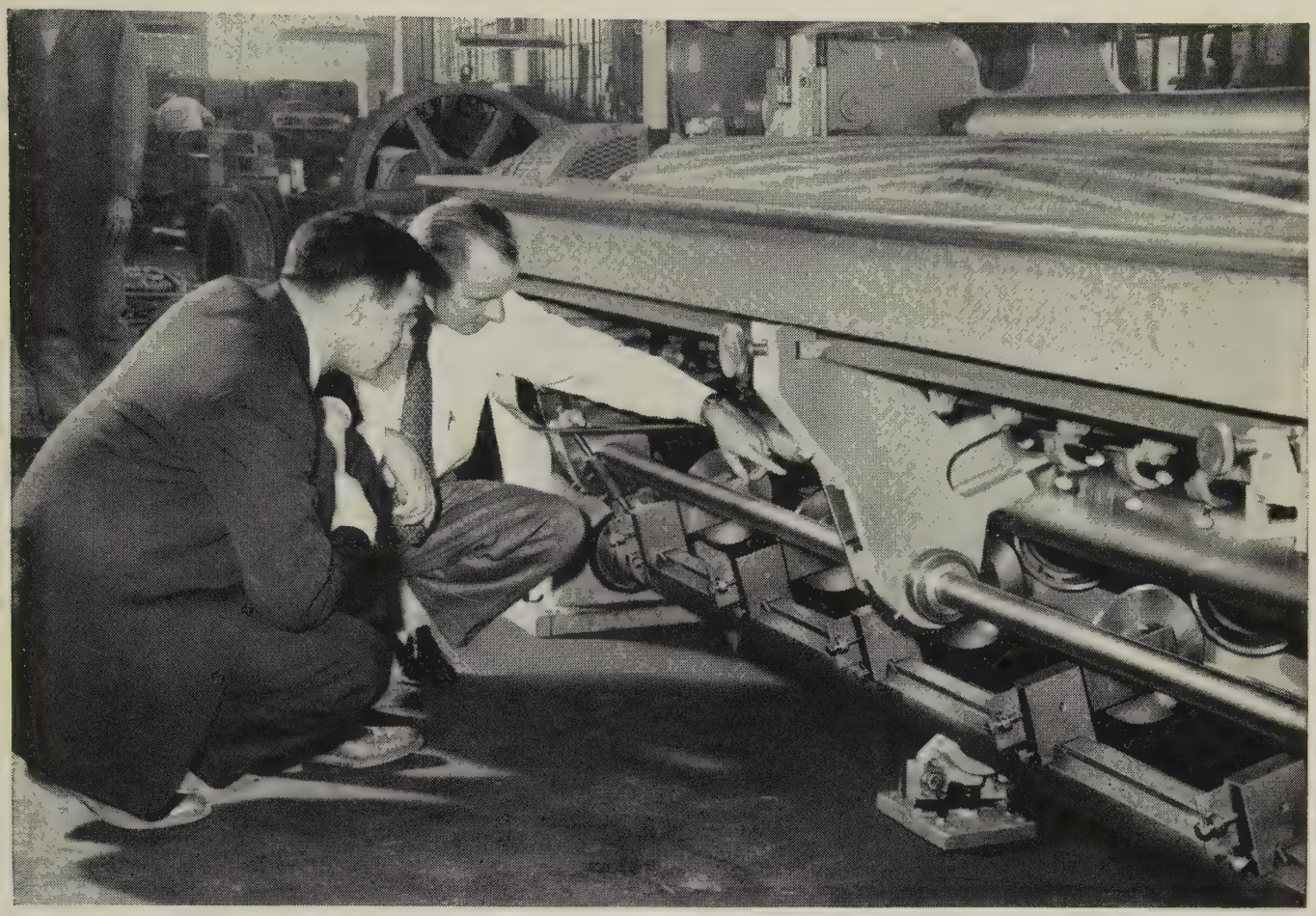
Irwin L. Taylor, formerly of the Detroit Sulphite Division, Scott Paper Co., is now Technical Director of the Rochester Paper Co., Rochester, Mich.

Ruel E. Taylor, formerly a manufacturer's representative is now Associate Director of Research of the Hudson Pulp & Paper Co., South Windham, Me.

William D. Thompson is now Sales Manager of the PMC Department, Hercules Powder Co., Wilmington, Del.

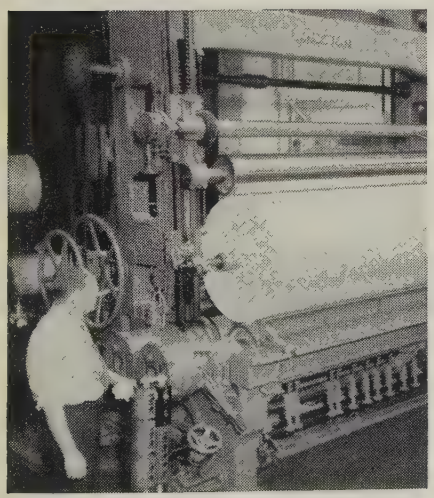
Sidney E. Thune is now Vice-President of National Starch Products, Inc., Chicago, Ill.

Julian E. Tobey, President of Appalachian Coals, Inc.,



A close-up look at Langston shear-cut slitters. The power-driven slitter drives the front slitter by friction. Paper is slit cleanly and accurately by shearing action of the two knives, like the opposing blades of a pair of scissors. Note the husky construction of these cutters—your insurance of long, dependable life at today's high running speeds. It means a better return on your investment.

Clean is the word for Langston Slitters & Winders



One of the three high-speed Langston Slitters & Winders in use at Hammermill Paper Co., Erie, Pa. This is a Model DA, handling high-grade writing paper in widths to 92 in., diameters to 50 in. Operates at 3500 fpm. Uses V-belt drives throughout and is driven by a variable speed motor.

Clean cutting. They cut like scissors instead of a knife. The famous Langston shear-cut slitters cut the paper cleanly—sharpening themselves as they run. Special steels carefully machined to close tolerances assure long dependable operation with minimum maintenance.

Clean rolls. Freedom from dust in the rolls is always desirable—frequently necessary. Because dust-laden rolls can lead to considerable trouble for the ultimate user of the paper. Self-sharpening Langston Slitters shear the paper cleanly, without the fragmentation that causes dust.

Clean plant. Freedom from paper dust is an advantage in your plant and your customers' as well. The air is cleaner. Operators are happier. There's less risk of fire, less dust on machines to gum up bearings, less of a housekeeping problem.

To enjoy all of these advantages, depend on Langston Slitters & Winders. Shearing cutters are standard equipment on Langston machines without special order or extra charge. Built in sizes up to 196 in. wide and speeds to meet your specifications. For complete information, write SAMUEL M. LANGSTON CO., CAMDEN, N.J.

LANGSTON *Leadership...by design*

Cincinnati, Ohio, was awarded the Bituminous Coal Research Association plaque for his contribution to industry-sponsored coal research.

Robert V. Touchette, of the International Paper Co., Ticonderoga, N. Y., is now in the U.S. Army.

Miss Carola Tritten, formerly of the Ward Paper Co., is now Assistant Professor of Paper Technology at Western Michigan College, Kalamazoo, Mich.

Henry J. Trolin, formerly of Sitroux, Inc., is now Vice-President in Charge of Production of Doeskin Products, Inc., New Hartford, N. Y.

Richard B. Valley, formerly student at the Institute of Paper Chemistry, is now Chemical Engineer for the Eastman Kodak Co., Rochester, N. Y.

Robert W. Wagner, formerly Quality Control Supervisor of the Mead Corp., is now with the American Box Board Co., Filer City, Mich.

Gordon F. Warner, formerly Chief Chemist of the Illinois Shade Cloth Corp., is now with the Dobeckmun Co., Bedford, Ohio.

Mortimer J. Williams of the Robert Gair Co. has been transferred from Tonawanda, N. Y., to New York City as Products Development Manager of the Boxboard Division.

Irving Witham is now Plant Engineer in Charge of Repairs, Maintenance and Engineering Projects of the Byron Weston Co., Dalton, Mass.

* * *

Nils Elkstrom has succeeded *Lars Ekelund* as the official corporate representative of Holmers Bruko & Fabriks A/B, Hallstavik, Sweden.

The name of the *Everett Pulp & Paper Co.*, Everett, Wash., has been changed to the *Simpson Paper Co.*

Industry Notes

Production

In February activity in the paper industry continued at a high rate as an estimated 2,269,000 tons were produced. This was about 3% less than the 2,338,000 tons reported for January by the Bureau of the Census, but 10% more than the output of February 1954.

Preliminary estimates made for the first quarter of this year indicate that the industry has made another record. First quarter production was at a new high, 7,171,000 tons, 2½% above the previous record high established in the first quarter of 1951 and 10% above production for the first quarter of 1954. Most grades of paper shared in this production increase.

The production of printing papers in February, estimated at 300,000 tons, was 4.5% less than in January but 5.6% more than February of last year. For the year to date the output of these grades has been 614,000 tons, about 4% more than for the first two months of 1954. Of particular significance is the fact that the volume of new orders has in each of these months exceeded shipments, causing the back-log of orders to rise to 361,000 tons, equal, on a 6-day basis, to about 29 days' production at the current rate of manufacture.

The production of fine papers continued at a high rate during the month as 115,000 tons of these grades were manufactured. The output of these papers is currently running about 16% ahead of a year ago. As in the instance of printing papers, orders received have thus far exceeded production and shipments have been met in part by a reduction of inventories. Unshipped orders, at 74,000 tons, are equal to about 15 days' production.

For the coarse paper group, production amounted to 305,000 tons and for the first two months of the year both production and shipments were about 5% more than for those months in 1954. Orders received during January and February, however, were about 10% above those for the same period last year and in each instance were higher than for any month in 1954. Orders for these grades also have been in excess of shipments, causing the mill back-log to rise to 299,000 tons.

For tissue papers, production for February is estimated to have been 135,000 tons and at the end of the first two months, the total of 273,000 tons was about 4% more than for the same period of last year.

Total paper production, exclusive of building paper and newsprint, was about 2% below that of January but almost 9% above that of February 1954. The production of newsprint, despite the shorter month, amounted to 110,000 tons, approximately the same as in January.

The production of paperboard, estimated to have been 1,010,000 for the month was 5% less than in January, but 9% more than for the same month last year. This segment of the industry has in the last two months produced 156,000 tons more than in the same two-month period of 1954. The back-log of orders continued to rise during the month and at its close amounted to 375,000 tons.

Value of Imports

The value of imports of papermaking raw materials, paper, paperboard and paper products for 1954 and 1953, as reported in the monthly FT 110 reports of the Bureau of the Census for 1954 and 1953 is as follows:

	1954 (P)	*1953*	*Per Cent Change*
Grand Total	$925,663,802	Not available	
Paper Base Stocks*	1,811,980	Not available	
Paper Manufactures*	1,220,160	Not available	
Total	922,631,662	933,331,093	−1
Pulpwood	31,697,237	33,708,818	−6
Wood Pulp	251,854,825	263,190,152	−4
Rags, Bags, Grasses, etc.	3,761,564	4,300,317	−13
Paper	609,863,823 (1)	609,276,824 (2)	—
Paperboard	11,569,854	14,360,935	−19
Paper Products	13,884,359	8,494,047	+63

(P) Preliminary.
(1) Includes newsprint at $595,644,010.
(2) Includes newsprint at $594,801,697.
* As of January, 1954, the Bureau of the Census includes a value totaling shipments individually less than $250 which applies to the starred groups (Paper Base Stocks covers pulpwood, wood pulp, rags, bags and grasses; Paper Manufactures covers paper, paperboard and paper products). These informal entries were not included prior to January, 1954 and to maintain consistency for comparison with last year the per cent change is based on the 1953 breakdown as shown above.

Pulpwood

Total receipts of pulpwood in January were reported at 2,816,000 cords, an increase of 422,000 cords above receipts for January, 1954. Domestic receipts increased 388,000 cords and imports, 34,000 cords.

Consumption continued at high levels amounting to 2,669,000 cords in January, an increase of 283,000 cords above January of last year.

Total inventories have been increasing moderately month by month since their low in June of last year, but were still considerably below inventories at the beginning of 1954. At the end of January this year, they totaled 5,215,000 cords, 424,000 cords below inventories at the end of January, 1954.

Wood Pulp

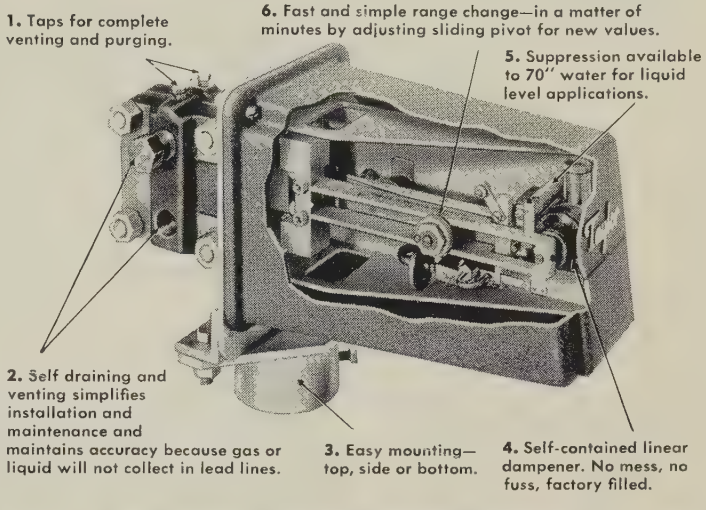
Production of wood pulp in January continued at a high rate, reaching a record 1,652,000 tons, based on preliminary Census Bureau data. The increase in production over January, 1954, amounted to 161,000 tons.

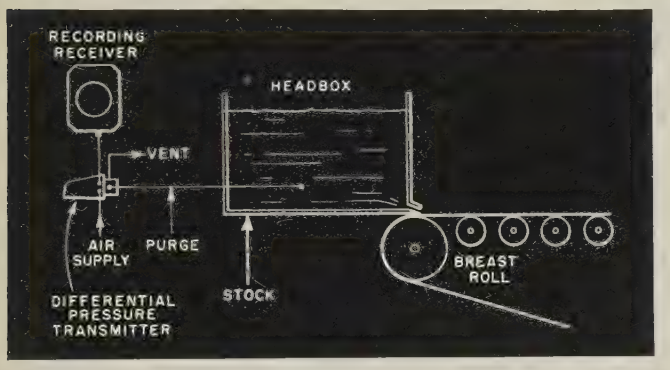
Consumption also continued at near record levels, January having been the second highest month reported. Consumption of 1,695,000 tons was an increase of 145,000 tons over January of last year.

Taylor Differential Pressure Transmitter EXCEPTIONALLY ADAPTABLE for flow, consistency and level measurement

The Taylor TRANSAIRE* Differential Pressure Transmitter (333RD) is ideal for many paper industry applications because — **1.** It's inexpensive and easy to install and to maintain. **2.** Changes in stock characteristics or seasonal demand cause no problems, due to quick, simple range change feature. **3.** No seal or condensate pots. Follows flows quickly because of low volumetric displacement.

A pneumatic force-balance transmitter, designed to convert differential pressure into an equivalent 3 to 15 psi output, it can be used to measure flow of liquid, steam or gas; liquid level or specific gravity. Pressure rating is 1500 psi, and it's available in any desired range from 20″ to 800″ of water. Call your Taylor Field Engineer, or write for **Bulletin 98097.** Taylor Instrument Companies, Rochester, N.Y., or Toronto, Canada.

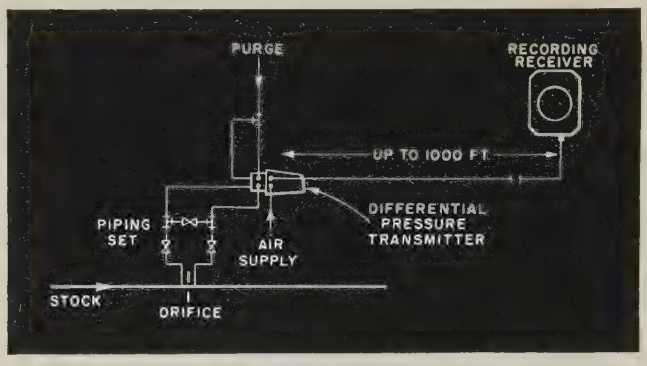

1. Taps for complete venting and purging.
6. Fast and simple range change—in a matter of minutes by adjusting sliding pivot for new values.
5. Suppression available to 70″ water for liquid level applications.
2. Self draining and venting simplifies installation and maintenance and maintains accuracy because gas or liquid will not collect in lead lines.
3. Easy mounting—top, side or bottom.
4. Self-contained linear dampener. No mess, no fuss, factory filled.



Headbox Level

PROBLEM: To measure headbox level precisely.

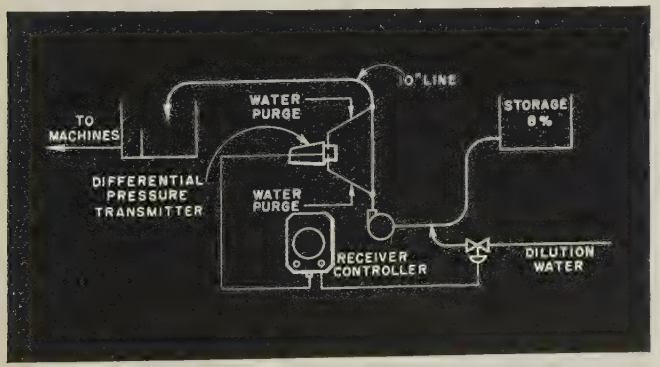
SOLUTION: The use of the 333RD Transmitter with suppressed range gives accurate measurement at all machine speeds. Effective suppression can be increased by having pressure tap at higher level.



Stock Flow Measurement

PROBLEM: To accurately measure stock flow, with consistencies up to 4%.

SOLUTION: The use of 333RD Transmitter and a segmental orifice plate. Purging can be made directly through the meter body, preventing clogging.



Consistency Measurement

PROBLEM: To measure and control stock consistency.

SOLUTION: Measure friction drop in the pipeline with 333RD Transmitter and control operation of the dilution valve. Fast, simple range change feature makes it easy to match operating characteristics of the stock.

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Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

*Reg. U.S. Pat. Off.

Estimated January exports of 51,400 tons were the highest on record and are indicative of the increasing world demand for wood pulp. In January, 1954, exports amounted to only 14,290 tons.

Imports too, were on the increase, totaling 160,267 tons in January, an increase of 15,454 tons above the comparable month last year. Imports from Canada increased from 111,896 tons to 125,123 tons, while overseas imports increased from 32,917 tons to 35,144 tons.

Inventories at the end of January were 662,000 tons, a decrease of 13,000 tons under December, but an increase of 20,000 tons above inventories at the end of January, 1954. Pulp mill inventories at the end of January were 172,000 tons and paper and board mill inventories were 490,000 tons.

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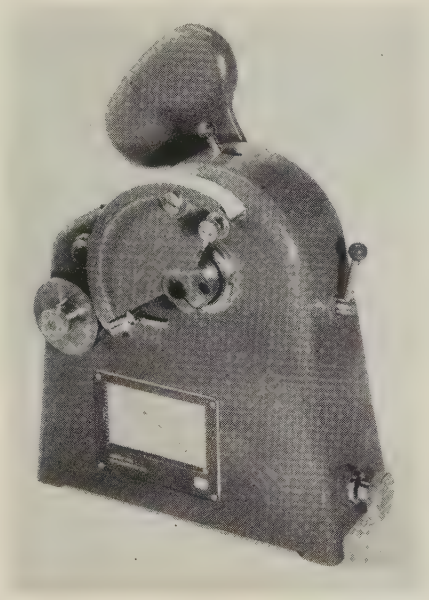

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WASTEPAPER

Thirty per cent of all the wastepaper consumed by the Eastern paperboard mills during the first four months of this year has been old corrugated boxes; 27% mixed grades, 28% news and 15% high grades.

The first quarter of this year was a good one for the purchase and consumption of paper stock, and, if the rate set by the Eastern mills during that quarter is maintained throughout the year, the 1955 consumption of wastepaper will exceed that of 1951, which was the biggest year of all time. The Eastern mills during that quarter purchased a greater tonnage of wastepaper than during any first quarter on record except 1951.

In the production of 26,657,000 tons of paper and paper board in the United States last year, there were consumed 19,034,000 tons of wood pulp, 8,064,000 tons of wastepaper, and 1,212,000 tons of other fibers. Thus of the total consumption of 28,310,000 tons of fibers 67.2% represented wood pulp, 28.7% wastepaper, and 4.1% other fibers. In 1946, the first year after the end of World War II, paper and paperboard production amounted to 19,278,000 tons, which were manufactured from 12,092,000 tons of wood pulp, 7,278,000 tons of wastepaper, and 1,383,000 tons of other fibers. Of total fibers consumed in 1946, 58.2% represented wood pulp, 35.1% wastepaper and 6.7% other fibers.

The Eastern Conservation Committee of the Wastepaper Consuming Industries has issued a leaflet for distribution by wastepaper users and dealers, advising suppliers that they will not purchase wastepaper containing asphalt, polyethylene, sulphur, and other objectionable materials.

RUSSIA

The Russian paper and pulp industry is in a period of intensive expansion. Included in the estimated 90 large integrated mills are several with an annual capacity of about 100,000 metric tons. The annual pulp and paper production in 1953 was about 2,300,000 metric tons, as against 400,000 metric tons in 1913. In the period 1951–1954, production of pulp and paper increased about 30%. Construction of new pulp and paper mills is very active, especially in the northern part of the country where many new mills have recently been built. Due to the shortage of wastepaper and the extravagant use of fuel, production costs could only be brought down less than 0.5% and not 3% as anticipated. Demand for paper and paper products is increasing at such a rate that the U.S.S.R. will have to import appreciable quantities in the near future.

FINLAND

The 258-in. newsprint machine recently erected at the Summa paper mill of Enso-Gutzeit Osakeyhtiö is expected to be in production soon.

The year 1954 was a favorable one for the Finnish pulp and paper industry.

The total mechanical pulp output was 847,700 tons, of which 193,177 tons was exported. Exports of sulphite amounted to 580,395 tons, and of sulphate 374,992 tons. Total chemical pulp production increased about 440,000 tons to 1,573,000 tons. Total paper exports were 661,855 tons, or 50,000 tons above the 1953 figure, and newsprint accounted for 391,750 tons of this. Total paper production was 847,000 tons, of which 448,000 was newsprint, 166,000 was kraft, and 233,000 was other grades. Paperboard production increased from 197,000 tons in 1953 to 255,000 tons in 1954 and exports amounted to 186,000 tons last year. Wallboard exports rose 15,000 tons to 59,495 tons, and total wallboard production was 127,000 tons.

Veitsiluoto Osakeyhtiö

Production was started at the beginning of this year at the mill of Veitsiluoto Osakeyhtiö, Veitsiluoto, Finland.

The paper machine is by Valmet Oy, manufactured at their works in Rautpohja. The trim of the machine is 435 cm. Its minimum nominal speed is 35 m.per min., maximum 550 m. per min. The basis weight is 40—350 g. per sq. m. The length of the wire is 35.5 m. The total number of drying cylinders is 62, of which 49 are paper driers, 12 are felt driers and one is the cooling cylinder. The drying section is divided into four groups. The machine is also provided with a secondary headbox. In the press section, comprising two suction presses, one straight and one smoothing press, space is reserved for a pick-up system soon to be installed. The future installation of a size press before the last group of drying cylinders is also taken into account in the plans.

Before entering the machine the stock is cleaned by means of knot-screens or "Vortraps," or both these devices in series. For this purpose, four Bird-screens manufactured by Karhula factories and 36 "Vortrap"-sets manufactured by the machine works of G. A. Serlachius Oy, in Mänttä, were installed in two stages.

A sectional electric drive was supplied by Allgemeine Elektricitäts Gesellschaft (AEG).

Rewinding is done by a winder of Valmet make which is placed at the end of the machine. A Jagenberg rewinder, the trim of which is 1600 mm., was installed for the winding of small-size rolls intended mainly for paper tube manufacture at the paper mill.

In the finishing department there is a 2800-mm. wide Jagenberg sheet-cutter and a Krause ream-cutter for the cutting of sheets of paper of various sizes.

The paper is cut in two halves in the winder and then transferred to the sheet-cutter. The sheet-cutter is provided with a calculator.

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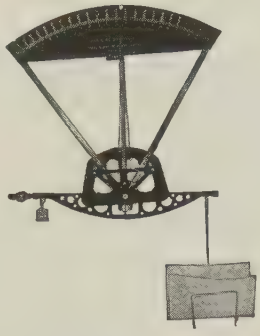

Indicates ream weight of paper from a single sheet. Scale ranges from 25 grams to 200 pounds. Features anti-friction bearings and truss beam construction. Dead beat motion allows minimum oscillating. Also available as a differential scale. Ideal for moisture content determinations.

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The glazing is done in a 12-roll supercalender manufactured by the firm Eck & Söhne.

For refining there are four Tampella Dilts hydrofiners and four jordan-mills manufactured by Enso-Gutzeit Oy, Lypsyniemi Engineering Shop.

The sulphite and semichemical pulp is pumped from the relevant mills and thickened in three Lindblad thickeners by Wärtsilä Oy and stored in chests. Two "Fibrella" hydropulpers by Jylhävaara Oy are used for bale-pulping. A similar pulper at the dry end of the machine handles the broke.

The proportioning of different qualities of stock is done in six Venturi tubes each provided with a regulator. Two of the meters register 0–2000 l. per min. and four 0–750 l. per min. The instrumentation is of Honeywell make and the venturi tubes, of Finnish manufacture, are supplied by Oy Control Ab.

Coupled with the proportioning of stock is the control of the surface level in the chests and alarm arrangements should the permissible maximum be exceeded. Instruments of Honeywell and Valmet make are installed for this purpose. The proportioning is based on a regular stock consistency obtained by means of Källe consistency regulators. The consistency regulators are viscosity meters which function on the same principle as water turbines.

Rotameters of the Rotameter Manufacturing Co. are used for proportioning rosin (Delthirna) quantities. The valves are manually operated. To maintain constant conditions the rosin is taken to the process from a constant level tank.

The proportioning of fillers is also continuous and is also done by means of rotameters and constant level tank as for rosin. The instruments are of the same make as the former. The manually operated valves used in regulating the flow of both rosin and filler are Saunders valves of Finnish make.

The proportioning of the color solution is also continuous. The solution is allowed to flow under constant pressure from a tank through rotameters and the quantity is controlled by Honeywell hand-operated valves. The number of instruments has been limited by using three-way cocks which enable the alternate regulation through one meter of the quantity of each color needed for the top and bottom layers. There are six of these meters, one for each color.

The quantity of alum solution is regulated by determining the pH of the stock pumped to the headbox. The alum solution is fed to the suction side of the secondary pump in the "Vortrap" system. Regulation is based on the pH of a stock sample taken from the distribution header and returned to the wire pit. The pH meter is by Beckman Instruments Co. The proportioning is done by means of a Honeywell regulator which is attached to the pH meter and which operates the alum valve.

The quantity of stock fed to the machine is regulated by the flow box, in which the surface level is kept constant, and determined by the positions of the V-shaped valve. The level in the flow box is regulated by a Honeywell regulator and the V-shaped valve is operated by hand. The same system is applied to the top and bottom layers.

At the refining department, 15 m. above sea level, there are a raw-water tank and a circulating water tank the levels of which are kept constant by Honeywell regulators and secured by an overflow. From these constant level tanks the water is led for dilution purposes to the Källe consistency regulators. In order to obtain an enclosed flow the overflow is returned to the suction side of the circulating water pump.

The pressure and the temperature of the steam for the paper machine is regulated by Källe regulators. For control purposes, the steam pipe system has been provided with a meter, manufactured by Valmet Oy, registering the pressure, temperature and flow of steam.

The air conditioning system is controlled by measuring the temperature and the humidity of the air in the most important places. For this purpose bulbs are placed at different

points and a twelve-point temperature measuring device (Multitempex) by Valmet Oy is used.

The instrumentation is chiefly concentrated on one panel in the refining department and on a second panel adjoining the press section of the paper machine (the machine tender's panel). The refining department is supervised by means of this panel. A diagram of the process is marked on the instrumentation panel and both normal-size and miniature instruments appear side by side. In addition to the proportioning devices, the chest level indicators, the control devices for the pumps, refiners and quick-closing valves and the kw.-meters for the refiners are installed on this panel. The last-mentioned are also connected with the machine tender's panel. This ensures cooperation between the machine tender and the refiner operator in supervising the refining governed by these meters Communication between the two is further facilitated by the installation of telephones. The control gear of the paper machine drive, the flow box control and pH regulating devices, together with their relevant registering meters, are connected up with the machine operator's panel.

The mill is provided with a modern heat recovery and air conditioning system, delivered by Suomen Puhallintehdas.

As the mill is situated close to old established factories which are furnishing it with raw materials, it is no exaggeration to say that the choice of raw materials for paper manufacture is great.

Although it would be technically feasible—considering the way in which the mill was planned and built and taking into account the available choice of raw materials—it is not the policy of the mill to alter the nature of its production from day to day. On the contrary, the production program of the mill will be planned with a long-term view to comply with the prevalent demand on the world market, i.e., orders of one and the same type will be combined into longer production series.

As no paper mill previously existed in the district, the first problem was the recruitment of trained workers. In order to reserve the work at the mill for the local inhabitants, and taking into consideration the fact that, as a rule, people like best to stay where they were born and bred, the management of the company decided to start training local employees in other paper mills. The training scheme was put into operation at the beginning of 1952, and the trained recruits returned in time to participate in the installation of the machines at which they were later to work. About 40 male workers were trained in this way.

Consulting Engineers Kaarlo Amperla participated in the planning of the mill from the outset. As soon as the decision to start building was taken, the drawing up of the final plans was entrusted to this firm through a contract signed between it and the Veitsiluoto Osakeyhtiö. The managing director of the firm, Kaarlo Amperla, B.Eng., has supervised the planning in close contact with the paper engineering experts of the mill.

—by Eero J. Muhonen, in *Finnish Paper Timber* 6, No. 2 (1955).

Middle South

Pulp, paper, and allied products are the Middle South area's fastest growing forest products industries. During the last two years, 13 new or expanded plants have been built in the area at a cost of over $35 million. Industries such as International Paper Co., Johns-Manville, United States Gypsum, Gaylord Container Corp., Crossett Industries, Flintkote, and others have located or expanded processing facilities in the Middle South, so that today the area is one of the nation's largest producers of pulp, paper, and allied products.

Gross sales by the pulp and paper industry in the area have increased 735% since 1939, a rate more than double the national average increase, and now total over $502 million annually. Employment by the industry exceeds 29,000 and annual payrolls now total over $123 million.

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During the period 1946 to the present, the pulp and paper industry of the Middle South has shown its greatest growth. Capacity of mills operating in the Middle South has increased 63.8%, with the area's mill capacity now over 17.2 million pounds per day (24-hour basis)—approximately 18% of the nation's total pulp capacity. Louisiana is the south's largest producer, with a mill capacity of over 9.5 million pounds of pulp per day, according to the latest figures available.

Among the area's diversified pulp and paper products are—wrapping paper, containers, bags, insulating board, sheathing, roofing, siding, interior finishes, cardboard and rayon pulp.

Middle South forests account for over 8% of the total United States forest area. (The Middle South land area is 4.88% of the United States.) In the relatively mild Middle South climate, operations are year-round, and trees grow rapidly, with loblolly and slash pines maturing to pulpwood size in as little as 15 years and to sawtimber size in as little as 20 years. Other Middle South tree species, at times, reach pulpwood size in as little as 5 years.

In 1953, wood cut for pulpwood in the Middle South totaled over 4 million cords—an increase of 233% since 1938. Production of both soft and hardwoods for pulp increased in the area. The amount of hardwood out for pulp has shown a spectacular increase following the recently developed method for producing rayon pulp from hardwoods by the sulphate process. The Middle South now produces 22% of the south's output of softwood for pulp and 48% of the output of hardwood for pulp.

Wisconsin

The state of Wisconsin is sponsoring a survey to determine how much the lower Fox River has been improved by the pollution control measures which have been taken over the past six years by pulp and paper mills, other industries, and municipalities.

Louisiana

The Southern Forest Experiment Station, 2026 Charles Ave., New Orleans, 13, La., has published the report of the Louisiana Forest Survey.

Tree Farms

The year 1954 marked a major turning point in the growth of the American Tree Farm System.

Programs were reorganized and strengthened in 18 states under the leadership of tree farm committees composed of some of the leading foresters in each state. The assistance of hundreds of other foresters in seeking cut and inspecting new Tree Farms and reinspecting existing ones added impetus to the program. Industrial foresters in particular played leading roles in invigorating the whole movement.

More people read about Tree Farms than ever before. Articles in the *Country Gentleman*, *Wall Street Journal*, and New York *World-Telegram*—to mention a few—brought a deluge of letters to my office. The letters came from people of all walks of life—lawyers, doctors, school teachers, farmers, and bankers—but they all had something in common. They wanted to become Tree Farmers. We tried to give every one of them service.

The result of all this upsurge of interest was that more tree farmers were certified than during any year in the 14-year history of the program. Last year hard-working Tree Farm committees in 36 states certified 1185 Tree Farms with 3,563,708 acres. I am sure that with the momentum the movement has gained, at least 2000 new tree farmers will be certified in 1955.

This year also will usher in several new Tree Farm states. Kentucky, Connecticut, Iowa, and Illinois already have new programs ready to go. Wisconsin is broadening its program to give recognition to small as well as large landowners. New programs are in the offing for Vermont and Delaware.

—by J. C. McClellan in *The American Tree Farmer*, Spring, 1955.

Forestry Publications

The Northeastern Forest Experiment Station, Upper Darby, Pa., has published its annual report for 1954 including a list of the Station's publications for the year.

Operations Research

"The Application of Operations Research to Industry" is the title of a report prepared by Johns Hopkins University Operations Research Office under contract with the Army. The report may be obtained at $1.75 per copy by ordering PB 111596 from OTS, U. S. Dept. of Commerce, Washington 25, D. C.

Packaging Engineering

Reinhold Publishing Corp., 430 Park Ave., New York, N. Y., has published a book titled "Packaging Engineering" by L. C. Barail, consulting packaging engineer.

Insulation Manual

The Magnesia Insulation Manufacturers Association, 1317 F St., N.W., Washington, D. C., has published the second edition of the "85% Magnesia Insulation Manual," containing new engineering and product data.

Printing Processes Seminar

The Printing Processes Seminar of the 16th Annual Forum of Packaging Institute, 342 Madison Ave., New York, N. Y., is available from the Institute at $2.25 per copy.

Packagers Directory

Packaging Institute, 342 Madison Ave., New York, N. Y., has published the third edition of the Directory of Contract Packagers available from the Institute at $5.00 per copy.

Paper Consumption

The apparent annual per capita consumption of paper and paperboard in the United States has increased from 58 to 384 lb. since 1899. Consumption of paperboard rose from 10 to 166 lb., white paper consumption increased from 47 to 217 lb. The grade showing the most spectacular increase was tissue, which increased from 0.8 to 19.0 lb.

Bagasse Newsprint

Reports from publishers who have used bagasse newsprint manufactured by Valentine Pulp and Paper Co., Lockport, La., indicate that the paper is satisfactorily strong and white, but that some printing difficulties are being encountered.

Dry Process Wood Board

The following is an abstract of a paper by James d'A. Clark, to be delivered at the annual meeting of the Forest Products Research Society in Seattle, Wash., June 20–23, 1955.

The main advantages and types of woody elements suited to the wet, the moist, and the dry manufacturing processes are reviewed. A new dry process is described, based on making the body of the board from whole (not disintegrated), relatively thick, cross-cut "wafers" from otherwise waste pieces of wood. The ends of the wafers are either smooth or jagged and, especially for the thicker wafers, the ends may taper away to nothing in thickness. The elements, for which several patents are issuing in United States and abroad, require less than 1½% phenolic resin binder to yield a board having a modulus of rupture of over 3000 psi. at the preferred density of about 0.7, corresponding to an M.R. of about 6000 p.s.i. at 1.0.

Following the successful operation of a demonstration 4 by 4 ft., two-opening press plant for over a year at Sandpoint, Idaho, new, and in some cases radically new, fully automatic equipment has been developed and tested for (1) producing the wafers from 4-ft.-long slabs and edgings at over 50 tons

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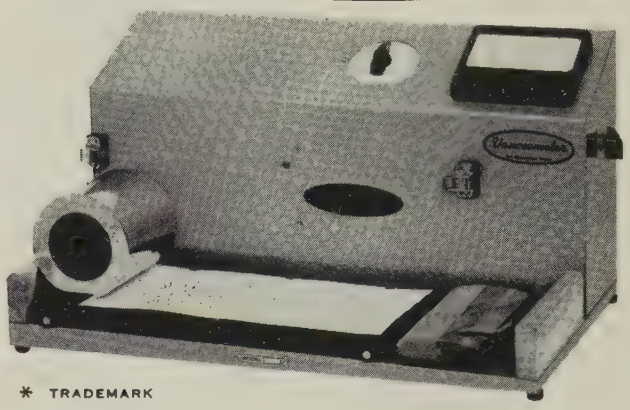

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per day with a 50-hp. motor, (2) storing the wafers in separate, large quantities and feeding a truly representative stream of each kind to the mixers, (3) felting the wafers continuously into neat, rectangular mats and in uniform layers, each of which may have a different composition, (4) pressing in a 12-opening, 4 ft. 6 in. by 16 ft. 6 in. platen press operated by a 4 by 16-ft. rectangular piston, (5) handling the top and bottom caul plates entirely automatically, including loading and unloading the press and separating the hot boards and cauls, (6) heat treating, then conditioning 6% moisture, and (7) trimming and cutting the finished boards to size.

Karl Damman, Paterson Parchment Paper Co.

Because of the simplified design of all the equipment especially the press, the cost of a complete installation to produce over 160,000 sq. ft. of 1/4-in. board (70 tons) per day, can be less than $750,000 and with the little labor and low resin usage, the new board, which can be made in any thickness and which is essentially a "multi-plywood" in its properties, can be produced at an attractively low cost.

New Alberta Mill

North Western Pulp & Power Co., owned jointly by St. Regis Paper Co. and North Canadian Oils, Ltd., will begin construction of its projected bleached sulphite pulp mill in Alberta, Canada, shortly and expect to complete the project in 1957. The mill will have a daily capacity of 400 tons rather than the 300 tons originally announced, and will be located at Hinton, about 200 miles west of the provincial capital city of Edmonton. More favorable operating conditions, including effluent disposal, influenced the change of location from Edson.

The project is estimated to cost $33,000,000. Equity capital of $10,000,000 will be provided equally by St. Regis and North Canadian. Financial arrangements have been concluded with the Royal Bank of Canada and the Bank of Nova Scotia. As needed during construction, these institutions will advance up to $25,000,000 to North Western on 5-year mortgage bonds. St. Regis will direct the design and construction of the mill and manage its operation. It will purchase part of the output for use in its own mills. The balance will be sold in the open market. Participation in this project will greatly enlarge the activities of St. Regis in Canada.

Using lodgepole pine and white spruce, the mill will have a perpetual pulpwood supply through a long-term timber grant from the Province of Alberta held by North Western Pulp & Power Co., presently covering about 3000 square miles (approximately 2,000,000 acres) of timberland. In addition, because of the increase in the capacity of the mill and future plans of the company, the Alberta government has granted the company an additional 3000 square miles of timberland as a reserve.

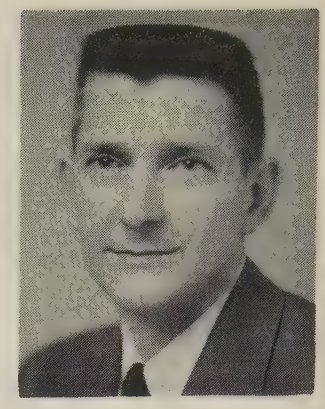
Engineering studies and design of the mill are now under way. H. W. Simond, Ltd., Vancouver, B. C., have been appointed consulting engineers for the project.

C-Z

Crown Zellerbach Corp. is planning a $750,000 green veneer mill near Portland, Ore. Chips from the mill may be used for pulp production at the company's other Oregon mills.

C-Z will install a new Beloit paper machine at Antioch, Calif. Auxiliary equipment will include six Jones Majestic jordans.

A. L. Smith, Paterson Parchment Paper Co.



D. G. Sturgeon, Paterson Parchment Paper Co.

Paterson

Karl Damman has been named general manager and reelected to the board of directors of Paterson Parchment Paper Co., Bristol, Pa. Arthur L. Smith has been elected vice-president in charge of sales, and D. G. Sturgeon has been appointed superintendent of maintenance.

Richmond

Richmond Pulp and Paper Co. of Canada, Ltd., Brompton-ville, Que., is planning a plant extension to house five more Waterous grinders and other equipment.

W. R. Grace

The Peruvian mill of W. R. Grace & Co. set a new production record of 19,255 metric tons in 1954. Current expansion will increase capacity by one-third. Grace's Paramonga mill produces over 60% of the paper consumed in Peru. The company's folding carton plant in Lima began operation early this year. At Paramonga, Grace was the first to produce paper from bagasse.

Consolidated

Consolidated Paper Corp. is planning to make vacuum pick-up installations on nine machines, at a cost of over $3.5 million. The new equipment is expected to raise the company's newsprint capacity by 100,000 tons annually and to effect savings through reduced sulphite content.

Abitibi

Abitibi Power & Paper Co. is undertaking a $6 million remodeling of its Pine Falls, Manitoba mill.

Glatfelter

P. H. Glatfelter Co., Spring Grove, Pa., has approved a $12.5 million improvement and expansion program. Plans call for erection of a 186-in. Rice Barton paper machine to operate at 500 to 2000 f.p.m., a new machine room, a new 250,000 lb. per hour Combustion Engineering steam boiler, and a billion-gallon water reservoir. Increased production of paper is expected to amount to 33,000 tons annually. Stock preparation equipment will be supplied by E. D. Jones & Sons Co., and will include double disk refiners, jordans, SLW stainless screens, and a Brokemaster for continuous handling of dry end broke.

Alaska Pine & Cellulose

Alaska Pine & Cellulose Ltd., Port Alice, B. C., will complete more than one-quarter of its $8 million expansion program by the end of this year. The program will increase the mill's production from 200 to 350 tons of pulp per day.

Whiting-Plover

George A. Whiting has been elected chairman of the board

of Whiting-Plover Paper Co., Stevens Point, Wis. Thomas Leech succeeds Mr. Whiting as president and treasurer. John Hoerres, secretary, was also elected vice-president.

Nepco

Nekoosa-Edwards Paper Co., Port Edwards, Wis., is currently installing a new recovery furnace at a cost of $\$1^1/_2$ million. Its rated capacity of 350 pulp-tons will permit expansion of pulping facilities by 100 tons. Expansion of Nepco's finishing room was completed late in 1954 at a cost of about $300,000.

Martin Paper Products

George B. Hills, Jr., has been appointed executive vice-president of Martin Paper Products, a division of Powell River Co., Vancouver, B. C.

National Container

Arnold Ginsberg has been elected a vice-president and director of National Container Corp., New York, N. Y. Mr. Ginsberg is assistant administrator of the company's converting plant division.

Standard Packaging

Standard Packaging Corp., New York, N. Y., has purchased Sterling Products Inc., Los Angeles, Calif.

Simpson

The Everett Pulp and Paper Co., Everett, Wash., is now known as the Simpson Paper Co.

No change in product or business policies is contemplated, as the new name merely reflects the change in ownership which occurred in 1952. At that time, the company was acquired by the Simpson Timber Co. and has been operated since, as a division of that organization.

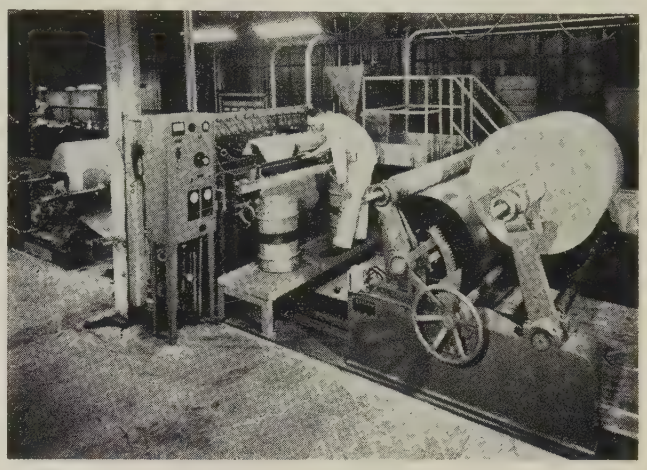
The Simpson Paper Co. was incorporated May 7, 1891, as the Puget Sound Pulp and Paper Co. Two paper machines were installed and a production of about 15 tons daily started in July, 1892. The mill was originally planned to manufacture machine finish book, manila and express wrapping paper, cover stock and commercial writing. In March, 1895, the name was changed to the Everett Pulp and Paper Co. Shortly after the turn of the century it was purchased from eastern capitalists becoming wholly locally owned.

Throughout the years expansion in plant facilities increased production to 35 tons per day and in 1926 a third paper machine was installed to bring the capacity to 70 tons a day. Early in 1951 extensive modernization was begun and given added impetus under the Simpson ownership resulting in quality improvements and a capacity in excess of 100 tons daily. The fully integrated mill today produces book, label, and offset papers as well as writing grades for home, business, and school consumption. A modern, well-equipped converting department is also a part of the growing and expanding Simpson Paper Co.

The Simpson Timber Co., a pioneer Washington corporation founded in 1895, and one of the West's leading wood product manufacturers, also operates divisions in Shelton and McCleary, Wash., and Arcata, Calif. Executive offices are in Seattle. W. G. Reed is chairman of the board and Thos. F. Gleed is president.

Guardian

Guardian Paper Co., Oakland, Calif., is operating its new



New polyethylene extruder-laminator at Guardian Paper Co.

72-in. Dilts polyethylene extruder-laminator, engineered by Dilts Machine Works Division of Black-Clawson Co., Fulton, N. Y.

Evert

Evert Container Corp. has completed its new corrugated box plant in Milwaukee, Wis., at a cost of about $1,250,000. The 100,000 sq. ft. building is covered with Fiberglas roof insulation.

Hudson

A. W. Aron has been named vice-president in charge of the Industrial Products Division of Hudson Pulp & Paper Corp., New York, N. Y., and Julian Mendelsohn is now vice-president in charge of the Multiwall Division.

Riegel

Riegel Paper Corp. has completed installation of its new 66-in. coating tower at Milford, N. J. The new coater, with normal and reverse roll coating heads, permits thicker coatings than Riegel's other three coaters.

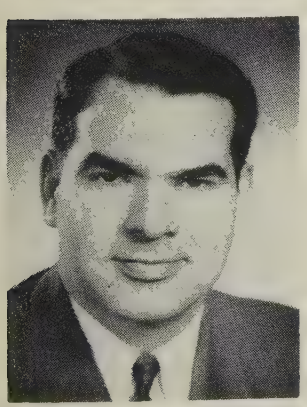
Riegel has ordered a 112-in. Murray chipper to be driven by an 800-hp. motor, and a Cowan screen to be used for primary screening of semichemical pulp.

Bowaters

Bowaters Southern Paper Corp., Calhoun, Tenn., established a new world's newsprint speed record of 2118 f.p.m. on April 27, 1955. The Bowaters no. 1 machine, manufactured by Beloit Iron Works, Beloit, Wis., was speeded up from 1720 to 2118 f.p.m. in $3^1/_2$ hr. Operation at this high speed was continued efficiently and quality was particularly well maintained.

Gair

Gair Woodlands Corp., Savannah, Ga., will award two $500 scholarships in forestry this year for study at the Forestry School of the University of Georgia, Athens, the University of Florida, Gainesville, or North Carolina State College, Raleigh.



G. B. Hills, Jr., Martin Paper Products, Ltd.

Arnold Ginsberg, National Container Corp.

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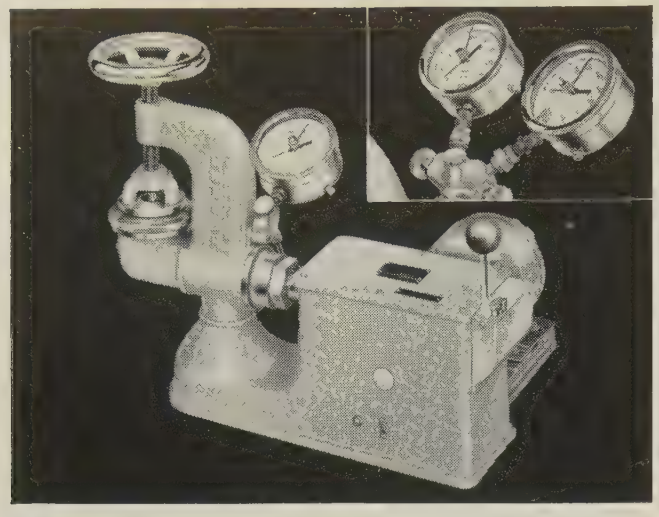
Model A—Motor Driven



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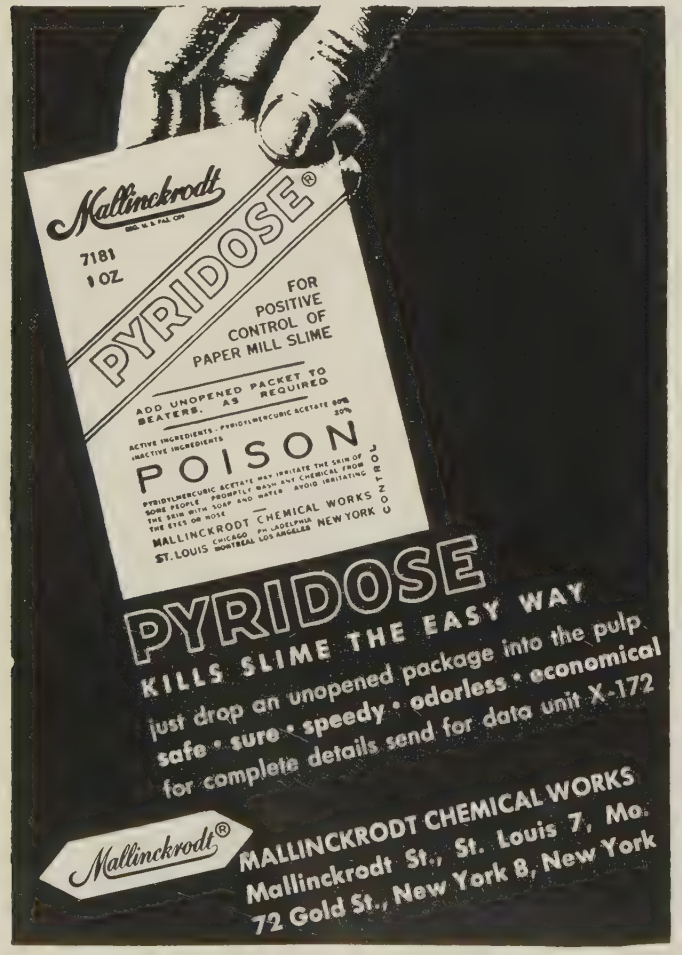
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Microcrystalline Wax

In the years before World War II, microcrystalline waxes were a small nuisance to petroleum refiners. Today they're a big business—a substantial chunk of the $100 million wax market.

Before War II, "microwaxes" (which must be removed from lubricating oil to keep it from solidifying at low temperatures) had a relatively limited market. But since 1945 and the start of the pre-packaged and frozen food boom, industry has been buying them up and melting them down at the rate of approximately 5 billion pounds a year.

The biggest customer by far for the new waxes is the paper industry, which uses them in milk cartons, bread wraps, and hundreds of different frozen food packagings, and as a bonding agent for the new laminated food wrappings. Other heavy users are the electrical industry, which impregnates condenser coils with them, and the textile industry—in which they are used as a waterproofing agent.

During the war the demand for protective packages, and the need for reducing the country's consumption of steel and tin normally used, speeded up the search for good substitutes. Paraffin wax then was the traditional coating for paper containers. Coated with paraffin, packages were moisture-proof, but they had to be handled with a great deal of care, from the military's viewpoint—the wax film cracked easily. And even with gentle handling, low temperatures caused the brittle paraffin coating to flake away from the paper, exposing it to moisture and moisture-vapor.

Microwaxes gave the military its answer to the question, "how to protect food rations and material from salt water, tropical climate and other natural hazards we can't avoid."

Tests showed the new waxes were tough, adhesive, and flexible. They withstood high temperatures without melting, low temperatures without chipping or cracking. These characteristics, added to the chemical stability common to all waxes, made the "micros" indispensable to the war effort. Since the war, they've made microwaxes one of industry's most useful materials.

The mushrooming laminated-wrap field also helped push microwax sales. These wraps consist of two or more layers of paper, bonded with microwax as the adhesive. They are useful because two or more different sheets, with different valuable properties, can be used simultaneously to take advantage of the best characteristics of each. For example: the cartons for "brown and serve" rolls are made of a standard boxboard, to which greaseproof paper has been laminated to keep shortening in the product from staining through the carton, making it unsightly on the grocer's shelf. Microcrystalline wax is used to bond the greaseproof paper to the carton—performing the dual function of an adhesive and of a moisture barrier which keeps the rolls fresh.

Microcrystalline wax obviously no longer is a refinery orphan. Today it's an independently wealthy member of the Petroleum family.

—by E. E. Brand, vice-president, L. Sonneborn Sons, Inc., Petrolia, Pa.

Cellulose Structure

Cellulose chemists are taking another look at structural theories as a result of recent degradation studies. Work in several laboratories now points to basic differences between wood and cotton cellulose in their acid hydrolysis behavior. Bengt G. Rånby and E. H. Immergut, University of Uppsala, told the ACS Division of Cellulose Chemistry that they not only find these differences but also are postulating that hydrolysis of cellulose fibers with dilute mineral acid can be subdivided into an initial fast reaction and a subsequent slower process.

Optical and electron microscopy and x-ray diffraction are being used in the Swedish laboratory to examine residues from hydrolysis of chemical grade wood pulp and cotton with constant boiling dilute hydrochloric acid. Cotton samples

give a straightforward reaction; behavior of the wood is more complicated and less easily explained.

The initial fast hydrolysis of both types to 80 to 90% yield implies a decomposition of the elementary cellulose fibrils into shorter rodlike fragments giving somewhat sharper x-ray reflections than the original fibers, explains Rånby. The initial hydrolytic attack proceeds preferentially along certain cleavage planes in the fibers giving irregular coarse fiber fragments, or micelles, 30 to 40 microns in width and 100 to 300 microns in length. The following slower hydrolysis to yields of 40 to 15% shows a very marked gradual decrease in the size of the fiber fragments.

Electron microscopy shows results of prolonged acid treatment. With cotton there is no noticeable effect on the cellulose micelles; there length and width remain unchanged even down to the point where only 15% of the original material remains. With wood pulp, on the contrary, micelle width decreases gradually from about 125 A at 80% residue to 95 A at 15% residue. Particle length remains practically unchanged. It is a decay on the surface of the particle not an end attack in the case of wood pulp, says Rånby.

X-ray diffraction patterns also show differences. For cotton there is no noticeable change in x-ray reflections during the course of prolonged hydrolysis. For the wood pulp the slow hydrolysis reduces the dimensions of the micelles making reflections somewhat wider and more diffuse.

Viscosity and osmotic measurements of nitrated residues showed this difference: with cotton there is no significant change in degree of polymerization (DP) during prolonged hydrolysis; with wood pulp, DP decreases by 35% during hydrolysis down to 15% residue.

Repolymerization? Studies at Brooklyn Poly are confirming these differences in hydrolysis behavior of wood and cotton but are also suggesting a new concept of late-stage repolymerization. Following decrease in DP by osmotic pressure change, H. P. Frank and Herman F. Mark find wood pulp samples degrade more rapidly in homogeneous acid solution than do samples of cotton linters.

Latest experiments show a hitherto unreported rise in the final portion of the DP-time curve. Light scattering techniques are being used to follow degradation of a low DP cellulose in 84.3% phosphoric acid. The techniques confirm early stages of degradation but as process continues there is definite indication that new macromolecules are being formed which increase turbidity, says Mark. Glucose samples tried in the light cell have also shown this increase in turbidity. Studies are continuing and special efforts are being directed to sample preparation in hopes that the light cell will give a better picture of the earlier stages of degradation as well.

At Princeton, Robert A. Martin and Eugene Pacsu are also carrying out degradation studies using phosphoric acid as hydrolytic agent. In contrast to earlier experiments lasting for only short periods (35 hr.), these degradations are being followed for several months. Samples of viscose, hydroviscose, and hydrocellulose in acid solution are held at 21 °C. and 100-ml. samples removed into ice at regular intervals. Precipitation and centrifugation, together with determination of remaining reducing sugars, are carried out.

Combined average degrees of polymerization are calculated for the entire process from analytical data. When plotted against time, initially high values decrease to a minimum after first two or three weeks of reaction, then gradually increase with time, approaching the value for cellobiose.

Suggesting that the results are not consistent with the concept of genuine molecular dispersion of cellulose in phosphoric acid, Pacsu offers these *possible* explanations: There may be foreign sugars such as xylose present in the molecule; there may be furanozide units; the molecular chain may be so entangled that glucoside linkages are not accessible; or there may be formation of micelles instead of chains.

—from *Chemical and Engineering News*, 33, No. 16 (April 18, 1955).

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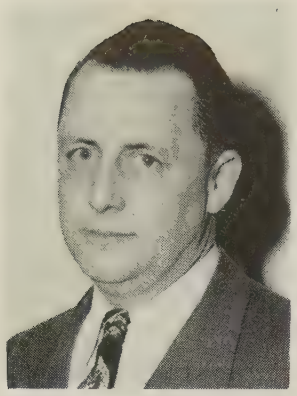
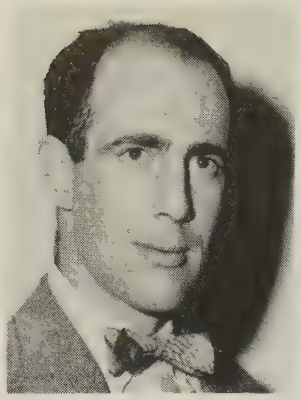


F. M. Myers, Columbia Box Board Mills, Inc.



F. M. Stout, Columbia Box Board Mills, Inc.

COLUMBIA

Francis M. Myers has been appointed assistant superintendent of the Chatham mill of Columbia Box Board Mills, Inc., Chatham, N. Y. Ferris M. Stout has been named technical director.

ST. REGIS

A. Thomas Easley has been appointed acting resident manager of the Deferiet, Carthage, and Herrings mills of St. Regis Paper Co., New York, N. Y. Lester J. Smith is now general superintendent of these three mills, and R. Stanley Donaldson is superintendent of the Carthage mill.

Justin H. McCarthy, chief engineer of the St. Regis pulp and paper divisions, has been named vice-president. John K. Ferguson, William W. Gordon, Gardiner Lane, Bernard W. Recknagel, Andrew F. Storer, and Charles A. Woodcock have been named assistant vice-presidents. J. W. Hartung has been appointed manager of the purchasing department.

John A. McDermott has been named supervisor of all St. Regis paper mills. John M. Victor is now general superintendent of the Jacksonville mill, and Sidney T. Dolan is superintendent of the Tacoma mill.

UNION BAG

All-time production records were chalked up during March in the paper mill, the pulp mill, the box plant, and the tall oil plant of Union Bag & Paper Corp., Savannah, Ga. And if the Savannah gray brick kilns were still working at the plant site, doubtless they too would have had a record month. Production was in the air.

The paper mill turned out a daily average of 1821 tons of kraft paper and board during March to beat the previous daily average record, set in October, 1953, of 1801 tons. During last month a total of 56,464 tons of finished product came off the six paper machines.

The pulp mill backed up this record paper production by averaging more pulp per day than ever before—1895 tons daily average production during March.

The paper mill also set a record during March in limiting down time on the paper machines. The plant's six machines, numbering some of the industry's largest averaged only 5 hours, 47 minutes lost between them, or less than one hour per machine per day. This is considered quite low, the previous figure being 6 hours, 43 minutes.

In the box plant records toppled too. During March the plant turned out the greatest average number of tons of finished boxes per day, and the greatest total tonnage of finished boxes, in history. Daily average box tonnage was 259 tons—the old record was 253 tons. Total monthly tonnage was 6083 tons, beating the old record of 5668 tons.

And the tall oil plant produced 3402 tons of crude oil for March at an average rate of 110 tons a day; both figures are records. It was the second straight month of production records for the tall oil plant.

MEAD

A 14-page booklet, "Meadol, A Lignin From Hardwood" has recently been published by The Mead Corp. It outlines the properties and industrial applications of the alkali hardwood lignin Meadol, as well as the chemical modifications of this lignin. The industrial applications section describes the use of Meadol in the asphalt, hardboard, ceramic, foundry (both conventional and shell molding process), ink, latex saturated products, petroleum and oil well drilling, rubber and electric storage battery industries. Copies may be obtained from The Mead Corp., Meadol Sales, Chillicothe, Ohio.

POTLATCH

A Dilts high-speed waxing machine, complete with continuous unwind and wind equipment, was recently installed at Potlatch Forests Inc., Pomona, Calif.

It consists of Kohler System unwind with flying paster, a 3-roll waxing section, polishing rolls, water finish section, cold rolls, and a Kohler System continuous winder with flying starter.

BERGSTROM

During the year 1954, the waste disposal plant of Bergstrom Paper Co., Neenah, Wis., processed over 300,000,000 gal. of deinked waste. From this waste the disposal system extracted 12,500 tons of material deposited as fill in the area adjacent to the plant. The fill material was composed of half clay and half fiber; 5000 truckloads of it.

Thirty thousand tons of waste paper were consumed to produce this large volume of waste. In the consumption of the waste paper, our bookstock system retrieved almost 20,000 tons of fiber. It is interesting to note that the production of this amount of virgin fiber would have required the consumption of 61,500 cords of wood. It is possible to obtain only $^1/_3$ of a cord of pulpwood from one acre of woodland which means that 184,500 acres are needed to produce this 20,000 tons of virgin fiber. This saving in pulpwood is a significant figure from a conservation standpoint.

The cost of operating our disposal plant during the year 1954 was approximately $30,000. This means an increase in the cost of producing our paper to the extent of about $1 for every ton of paper made and sold.

It is recalled that this large volume of waste material formerly went to the municipal sewerage disposal plant. Although our tax dollars paid for the operation of the municipal plant, it can be seen that the municipal plant was relieved to the extent of this volume. This resulted in a savings to all taxpayers in our community.

Our research in waste disposal is continuing without letup. We are constantly searching for new ideas to render our disposal system more efficient and economical. Through research, we hope to reduce this dollar-per-ton competitive penalty with which we now must live.

—by N. H. Bergstrom in *Rolls and Reams*, April, 1955.

SCOTT

Scott Paper Co. has announced a licensing program under which it will grant licenses covering the use of its recently patented improved processes for bleaching groundwood pulps.

On April 26, 1955, U. S. patents 2,707,144, 2,707,145, and 2,707,146 were granted to Scott on processes involving the use of hydrosulphite for bleaching wood pulps. Scott has patent applications pending on these processes in Canada as well as other foreign countries. Use of the processes results in brighter pulp as well as reduction in the cost of bleaching.

Since 1952, two Canadian pulp mills have been using the processes to produce bleached groundwood pulp for Scott, and such interest has been expressed in the processes that

Scott has decided to license them on the basis of a royalty on one-half cent per pound of hydrosulphite used. Scott anticipates that the nominal royalty rate will not be burdensome to licensees because use of the processes not only raises the maximum attainable brightness of the pulp, but also reduces the bleaching cost per point of brightness. The royalty to be charged will average only 10 cents per ton of pulp bleached by the process.

After consultation with representatives of Virginia Smelting Co., Rohm & Haas Co., and E. I. du Pont de Nemours & Co., Scott has evolved a licensing program which it believes will be attractive to the industry.

Information concerning the processes and licensing program can be secured from any of the three manufacturers referred to above or by writing directly to Scott's Patent Counsel at Chester, Pa.

Thilmany

The second oldest wood pulping mill in the country as to years, but one of the newest as to processing—that's Thilmany's pulp mill. From the coarse groundwood of 1883 to today's several grades of chemical pulp is a long way, marked by a good many efforts to keep up with modern developments and rising costs.

The latest major developments in this struggle were the result of a program drawn up in 1950 by Pulp Mill Superintendent Paul West, and adopted that same year by the board of directors. As a result of that action, the company has invested about $3,000,000 over the 4-year period in modernization of the mill. Pulp production has increased from 150 tons a day to 225, at a lower cost per ton.

That program is today virtually complete. The last item, a system to pump "slush" pulp containing 93% water, directly from storage to the paper machine beaters, was put in operation in mid-March.

But let's take a look at the beginning of the operation. The pulp mill operates what might be called a "disassembly line," since what it does basically is to break a log down into its principal components, fiber and lignin, and then prepare the fiber to be used by the paper machines.

Into the mill every day go about 20 gondola-loads of 8-ft. logs. The wood enters by way of the hot pond, one of the first items on the modernization program. This soaking process is intended to remove surface dirt and make bark removal easier. The logs are conveyed from the pond to another modernized operation—barking in a 45-ft. long, 12-ft. diam. revolving drum. Prior to the installation of this drum in 1950, logs had to be cut in half. This cost time and money, and resulted in waste, for the ends of the short logs would be frayed, or "broomed," in barking, a condition which adversely affected chipping. An example of waste reduction is afforded by the fact that the bark removed here is sent to the boiler room as fuel.

Clean of bark, the logs are conveyed to a chipper, also a part of the program. An 88-in. disk holding 10 knives whirls around at 360 r.p.m., and reduces an 8-ft. log to chips in 2 sec. The chips are hurled to modern vibrating screens which return any oversized pieces to a smaller chipper for another going-over.

All this operation is, as nearly as possible, continuously flowing. That principle operates throughout the mill. Prior to late 1951, the cooked pulp from the digesters where the chips are cooked was washed in diffusers, great tanks much like the digesters themselves. One "cook" was blown into a diffuser and slowly washed with hot water to free it of the liquor used in the digesting process.

Even with four diffusers to one digester, the slow washing process represented a bottleneck. And at that time the diffusers were well-worn and had to be replaced.

Greater efficiency and a worth-while saving would be effected, Thilmany management reasoned, by installing a system which would wash continuously as much pulp as the digesters could put out.

This was installed in 1951, and the space formerly housing the diffusers provided room for badly needed pulp storage and another unit of the modernized system—10 lines of flat screens which were started up in the fall of 1953. This screening system pays dividends by sending "rejected" fibers to a mechanical refiner and back into the screening system; previously such fibers had to be used in making lower grades of paper.

In the meantime, an additional digester had been installed to take advantage of increased capacity. This greater production created some new problems in connection with the recovery of lime and saltcake, two chemicals which are used in great quantities in making pulp. And at the same time there arose a need for higher-pressure steam than was available, to drive new electricity-generating equipment.

A new 250-ton recovery boiler was the answer to the problem of steam generation and saltcake recovery. A new 150-ft. long lime kiln proved to be what the doctor ordered for increasing lime recovery.

Coupled with both saltcake and lime recovery must be mentioned the antipollution aspects of both processes. In connection with the recovery boiler, Thilmany pioneered a new installation to cut down smoke pollution, and also increase the efficiency of chemical recovery. Known as a Venturi Scrubber the installation forces gases from the burning of the "black liquor" through a "shower bath," which pulls chemical dust from the smoke, preventing it from becoming a community nuisance.

The lime kiln not only makes operations more economical by recovering lime to be used again, it keeps the lime sludge in the plant and out of the river, where it might otherwise have been disposed.

The slush pulp system is designed to carry out the continuous flow idea, too. It's apparent that the process of making pulp into sheets of "wet lap," only to make the wet lap back into pulp for the paper machines is inherently wasteful. It's also tough to beat, for the storage of pulp is difficult and expensive.

The new pumping system will help to eliminate some of that waste, however, by pumping slush from storage directly to the paper machine beaters, with a capacity of 150 tons a day.

Modernization, of course, is a process without an end. In May a new paper machine wash-up system went into operation, reclaiming fiber which otherwise might be lost to the river. A new causticizing system, and a new bleach plant are part of a long-range program.

Syracuse

A research fellowship sponsored by the American Pulpwood Association at the State University College of Forestry, Syracuse, N. Y., at $2400 on a 12 month basis is currently open. The graduate fellow would work on the development of a Directory of Research in Growing and Harvesting Pulpwood. This directory, according to W. S. Bromley, executive secretary of the American Pulpwood Association, will serve the pulpwood industry and public agencies as a reference guide to the progress of experimental work throughout the country and as a more effective medium of coordination of efforts in this field.

The National Science Foundation has awarded $45,000 to the College of Forestry to support a 3-year chemistry research project directed by Michael M. Szwarc, professor of physical and polymer chemistry in forestry activities.

University of Washington

The University of Washington has established a scholarship fund in memory of the late Henry K. Benson, a member of its faculty for 50 years.

M.I.T.

The Massachusetts Institute of Technology, Cambridge, Mass, will present a two-week special summer program in "Colloid Science" from July 11 to 22.

Furniture Supply Fair

Thilmany Paper Co., Kaukauna, Wis., and Jiffy Mfg. Co., Hillside, N. J., will exhibit their products at the National Association of Furniture Manufacturers Supply, Equipment, and Fabric Fair, to be held at the Conrad Hilton Hotel, Chicago, Ill., Aug. 28 to Sept. 1, 1955.

Lubrication Conference

The Second Lubrication Conference, jointly sponsored by the Lubrication Activity Group of the American Society of Mechanical Engineers and the American Society of Lubricating Engineers, will be held Oct. 10–12, 1955 at the Antlers Hotel, Indianapolis, Ind.

Sandwell

P. R. Sandwell & Co., consulting engineers, Vancouver, B. C., is supervising more than $100 million worth of construction in six countries. Details of the firm's current projects follow.

Pakistan
- A 35,000-ton annual capacity newsprint mill in East Bengal on the southern part of the Ganges Delta. Also a town, central power plant.
- Estimated cost $20,000,000.
- Estimated construction time $2^1/_2$ years.
- Contract is with the Pakistan Industrial Development Corp. as a part of the rural industrialization of the country.
- Wood to come from the 1600-square mile Sunderbans Islands forests.
- Wood to be used is from the Gewa trees, a broad-leafed native tree.
- Contracts will be awarded in May.
- Sandwell and Co. to establish resident staffs at Khulna, near the millsite and Kerachi, the capital.
- Four key personnel from Vancouver to supervise construction, headed by Peter Vakmoies.

Mexico
- Tuxtepec Paper Co., near the Gulf Coast, east of Mexico City.
- 30,000 tons annual capacity for Mexican market.
- Project also includes town and forest development.
- Estimated cost $10,000,000.
- Sandwell and Co. surveys took 18 months, headed by Sven Quist.
- Engineering has started, construction work to begin at end of rainy season in September.

England
- Mill expansion in southern England for production of magazine and newspaper newsprint.
- Part of the pulp is shipped from B. C. to England.

Sweden
- Mill expansion in northern Sweden.
- Total cost of English and Swedish mill expansions is $15,000,000.

New Zealand
- $40,000,000 Murupara project at Tasman to start producing pulp in May, to be in full production this summer.
- Caxton mill, next to Tasman, under construction.

Brazil
- Survey underway by Sandwell and Co. on newsprint and kraft paper mill in southern Brazil.
- Estimated cost of mill $20,000,000.

France
- Survey underway in southern France to use pine forest resources.
- Discovery of oil and natural gas has made production of paper economical.
- Estimated cost of mill $30,000,000.

United States
- Pulp and paper mill at Albany, Ore., to be completed by the end of this year.

New Building
- Work will start immediately on a new building at Nicola and Alberni with occupation expected in November.
- Two stories, with a single-story wing, 6000 sq. ft. Can be expanded.
- Architects are Gardiner Thornton and Partners.

Fuller

Fuller Co., Catasauqua, Pa., has published a bulletin (F-5) describing its line of roll and vane-type feeders and rotary valves.

Downingtown

Downingtown Mfg. Co., Downingtown, Pa., has produced a 16-mm. film on the 4B2 Fibrepulper, available without charge from the company's Public Relations Dept.

Francis J. Merkt has been appointed a sales representative for Downingtown.

Ozalid

Ozalid Division of General Analine & Film Corp., Johnson City, N. Y., recently established a new world record production of diazo-sensitized paper by coating nearly a million square yards of sensitized material in one uninterrupted 49-hr. period.

D. J. Murray

A. W. Plier has been re-elected president and general manager of the D. J. Murray Mfg. Co., Wausau, Wis.

A photograph of the late Fred C. Boyce, for many years president of D. J. Murray Mfg. Co., Wassau, Wis., presented at the recent annual meeting of the company by a group of the firm's employees who wanted to show their gratitude to the late president and board chairman of the company, is accepted on behalf of the company by its president, A. W. Plier. Shown with him is F. C. Boyce, son of the late president, and a director of the company. The photograph is 27 by 31 in. bordered in black walnut panels with exquisite carvings representing the activities in which the late Mr. Boyce was deeply interested

Monsanto

Monsanto Chemical Co., Dept. SB, Springfield, Mass., has issued a bulletin describing Scriptite 33, a new wet strength resin for paper.

Hooker

The consolidation of Durez Plastics and Chemicals, Inc., with Hooker Electro-chemical Co., Niagara Falls, N. Y., has been approved by the stockholders of both companies. John F. Snyder has been elected a vice-president of Hooker. Alfred W. Hammer is appointed vice-president of Durez Plastics Division in charge of sale and development, and Edward W. Mathias has been named treasurer of the Durez Plastics Division.

Hooker celebrated its 50th anniversary on May 5 of this

year. Founded in 1905, Hooker now produces about 100 chemicals, all using chlorine, caustic, or hydrogen in their manufacture. Its annual sales run about $45 million.

NORTON

Norton Co., Worcester, Mass., is equipping a new plant at Santa Clara, Calif., for the manufacture of grinding wheels. George A. Garrison has been named plant manager.

FISCHER & PORTER

Fischer & Porter Co., Hatboro, Pa., has issued a catalog (no. 80-20) of its stock precision-bore products in quartz, Vycor, and glass. F & P catalog 58-15 covers multiple pressure readout systems to speed up data handling for process industries, wind tunnels, engine test facilities, and marine model basins.

BULKLEY, DUNTON

Paul S. Cooper has been appointed to handle Colloidair Separator Water Clarification equipment in New England for Bulkley, Dunton Processes, Inc., New York, N. Y.

SHELL

Shell Chemical Corp., New York, N. Y., is building a hydrogen peroxide plant at Norco, La. A second plant, to be built later, will produce acrolein, and a third will use these two products to manufacture glycerin.

J. M. HUBER

J. M. Huber Corp., 100 Park Ave., New York, N. Y., has issued a leaflet on Zeolex 23, a new high brightness filler pigment.

RODNEY HUNT

Rodney Hunt Machine Co., Orange, Mass., has published a handbook on Rubber Rolls available on request to those using rubber rolls and at $2.00 per copy to others.

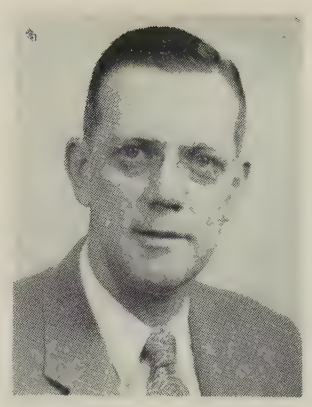
PETTIBONE MULLIKEN

Pettibone Mulliken Corp., 4700 W. Division St., Chicago, Ill., has published a brochure (P 185) describing the Pettibone Cary-Lift, an all-purpose loader specifically designed for operation in unpaved, soft areas typical of mill yards.

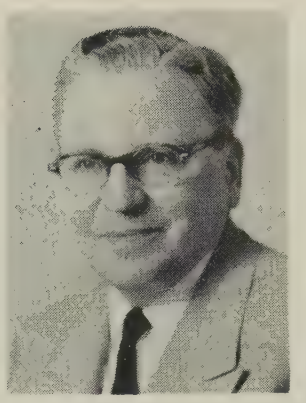
HERCULES

W. D. Thompson has been appointed sales manager, miscellaneous paper chemicals, for the Paper Makers Chemical Dept. of Hercules Powder Co., Wilmington, Del.

The Pettibone Cary-Lift



W. D. Thompson, Hercules Powder Co.



P. H. Goldsmith, Dominion Engineering Works, Ltd.

DOMINION ENGINEERING

Philip H. Goldsmith has joined the staff of Dominion Engineering Works, Ltd., Montreal, Quebec, as sales manager, Paper Machinery Division.

GRAVER

J. D. Crell has been appointed sales engineer for the New York City Sales district of Graver Water Conditioning Co., New York, N. Y.

Graver has appointed the Allen-Shuff Corp. of Memphis and Nashville as sales representatives for Graver industrial, municipal, and industrial waste treatment equipment.

Graver is offering new permanent flow diagrams made of laminated plastic, for mounting near the central control panel.

G.E.

The new Summa mill of the Enso-Gutzeit Osakeyhtio in Finland is equipped with a 2000-hp., d.c. motor supplied by General Electric Co., said to be the most powerful paper machine drive in the world. All motors and control associated with the drive and the rewinders were furnished by G.E.

G.E.'s Wire and Cable Dept., Construction Materials Division, Bridgeport, Conn., has published a new booklet (No. 19-224) "Wire and Cable for the Pulp and Paper Industry."

GEIGY

Geigy Dyestuffs, Division of Geigy Chemical Corp., has transferred its New England operations to 33 Industrial Place, Newton Upper Falls 64, Mass.

NALCO

H. R. Powers has been appointed vice-president in charge of Industrial Division sales, Gage Averill becomes vice-president in charge of Catalyst Division sales, and Alphonso Cantalini is now vice-president and European manager of National Aluminate Corp., Chicago, Ill. H. E. Berg, W. H. Thompson, and A. O. Jaros have been appointed assistant vice-presidents.

SHEFFIELD

The Sheffield Corp., Dayton, Ohio, has published instantaneous reading Engineering Data Sheets on the Sheffield Paper Smoothness and Paper Porosity Checkers.

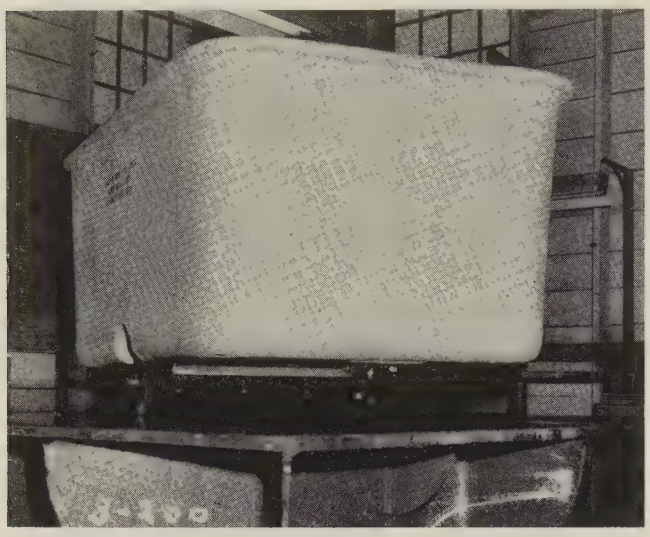
FIBERGLAS

Fiberglas roof insulation, produced by Owens-Corning Fiberglas Corp., Toledo, Ohio, was used on the new corru-

gated box plant of the Evert Container Corp. in Milwaukee, Wis.

PATTON

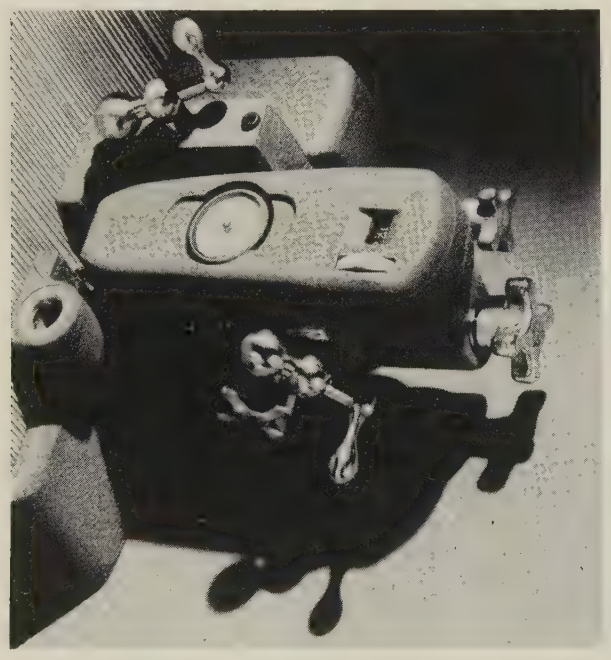
Patton Mfg. Co., Springfield Ohio, is offering a new lightweight broke cart, the Plasticart, made of Fiberglas.



The Plasticart made by Patton Mfg. Co.

TABER

Taber Instrument Corp., Section 80, 111 Goundry St., North Tonawanda, N. Y., has published a bulletin (no. 5501)



Measuring toughness of asbestos-cement shingle

describing the Dyhedron Tester for determinating the dynamic hardness and natural lubricity of materials.

SCAPA

Scapa Dryers, Inc., a recently formed American company sponsored by Scapa Dryers, Ltd., Blackburn, England, and Ayers, Ltd., Lachute, Quebec, will locate its drier felt plant at Waycross, Ware County, Ind. The president of the new company is Thomas Hindle, and Donald M. Brass will be in charge of production and service. Sales will be handled by Morey Paper Mill Supply Co., Fitchburg, Mass.

CONDI

Rohe V. Pennington has joined the staff of Condi Engineering Corp., Pittsfield, Mass. Condi has taken over its new quarters in the Central Block, 73 North St., in Pittsfield.

J-M

Charles B. Hann has been appointed manager of the Chemical Section of the Johns-Manville Special Industries Dept.

BECCO

Eric A. Hansen has retired as manager of the New York territory of the Becco Chemical Division, Food Machinery and Chemical Corp., Buffalo, N. Y. Albert L. Shutts is now in charge of sales and customer service operations in the New York territory, and will be assisted by E. M. Roth, Jr.

Becco has issued a bulletin (No. 66), "Becco Laboratory Procedures for Pulp Bleaching."

U. S. TESTING

United States Testing Co., 1415 Park Ave., Hoboken, N. J., is offering the Universal Stiffness Tester, developed by the

Universal stiffness tester developed by United States Testing Co.

company from the instrument described by Worthington and Carson in the *Journal of the National Bureau of Standards*, December, 1952.

INDUSTRIAL NUCLEONICS

Industrial Nucleonics Corp., Columbus, Ohio, is offering an industrial computer, the AccuRay Model D-5, for analyzing the production of sheet materials.

A-C

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has published a bulletin (no. 52B6083C) describing the company's Model C-3 supporting adapter "Electrifugal" pump.

A-C bulletin 14B8171A describes the company's heavy duty d.c. contactors, including the new type 522 units and control relays for steel mill and similar heavy duty applications.

Robert S. Stevenson has been elected president of A-C.

CLARK-AIKEN

The Clark-Aiken Co., Lee, Mass., has issued a bulletin covering the complete line of the company's cutter-layboy units.

KOHLER

Stanley W. Johns has joined John B. Kohler, paper consultant, Crystal Lake, Ill., as chief of special project design.

S. W. Johns, John B. Kohler, consultant

FOXBORO

C. C. Fuller has been appointed vice-president, H. O. Ehrisman, general sales manager, and J. J. Burnett, field sales manager of the Foxboro Co., Foxboro, Mass.

C. C. Fuller, Foxboro Co.

H. O. Ehrisman, Foxboro Co.

NATIONAL STARCH

C. G. Caldwell, J. F. Fitzgerald, R. W. Merritt, and S. F. Thune have been appointed vice-presidents of National Starch Products, New York, N. Y.

National Adhesives Division of National Starch has issued a revised edition of its booklet "How to Handle Adhesives for Transparent Films."

ROHM & HAAS

Rohm & Haas Co., Resinous Products Division, Washington Square, Philadelphia, Pa., is producing two new acrylic emulsions, Rhoplex X-52 and B-85, offering superior hardness with consequent resistance to blocking and to water absorption.

BORDEN

Herbert H. Clarke, Jr., has been appointed executive vice-president of the Borden Co.'s Chemical Division, 350 Madison Ave., New York, N. Y.

INGERSOLL-RAND

Ingersoll-Rand, 11 Broadway, New York 4, N. Y., has published a catalog (form 5200-A) describing the I-R line of Impactools for running nuts, bolts, cap screws, and other type fasteners.

A new I-R bulletin (Form 1540) describes the Model 20T compressor equipped with I-R channel valve.

KELCO

Kelco Co. has moved to 120 Broadway, New York 5, N. Y.

DICALITE

Dicalite Division of Great Lakes Carbon Corp. is celebrating its 25th anniversary this year. During its 25 years of operation, Dicalite has shipped over 50,000,000 bags of diatomite products from its two plants in California and one each in Oregon and Nevada.

The unique and intricate structure of the diatom particles, combined with great porosity, makes diatomite of great value in the filtration of hundreds of different liquids—acids, pharmaceuticals, and such antibiotics as streptomycin and aureomycin; in filtering other liquids such as water, dry cleaning solvents, beer, vegetable oils, sugar, and syrups. Diatomite also has many uses in paint, paper, and insulation; as a conditioning agent for chemical fertilizers; and other applications where its light weight and other properties give it value as a filler or extender material.

Great Lakes Carbon Corp. acquired The Dicalite Co. in 1944, and merged into its organization as the Dicalite Division. Additional deposits at Lompoc, Calif., and a third deposit and plant at Basalt, Nev., were added. In 1952 Great Lakes Carbon Corp. completed building and put into operation the fourth Dicalite plant at Lompoc, Calif., which in three years of operation has become well known for its advanced features of design and engineering.

ANTARA

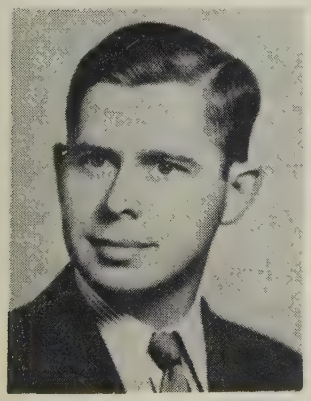
Antara Chemicals, a sales division of General Aniline & Film Corp., New York 13, N. Y., has published a second edition of its catalog of products.

DAJAC

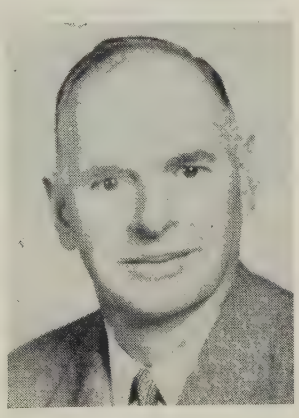
Dajac Laboratories, Chemical Division, The Borden Co., Leominster, Mass., has issued a catalog of reagents for medical research and biochemical testing.

CONTAINER LABS

James J. Larkin has been appointed director of quality testing for Container Laboratories, Inc., 228 N. LaSalle St., Chicago, Ill.



C. G. Caldwell, National Starch Products, Inc.



J. F. Fitzgerald, National Starch Products, Inc.

R. W. Merritt, National Starch Products, Inc.

S. F. Thune, National Starch Products, Inc.

Chicago Bridge & Iron

Chicago Bridge & Iron Co., 332 S. Michigan Ave., Chicago 4, Ill., has developed a new high vacuum brazing method for cladding metals, designated "Horton Clad."

Taylor

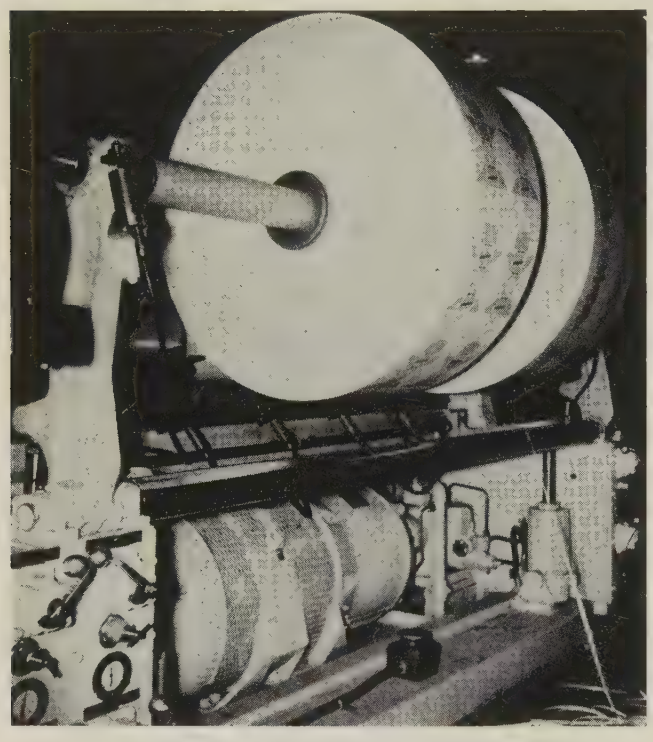
Taylor Instrument Cos. have moved their San Francisco offices and plant to San Leandro, Calif.

Black-Clawson

The Black-Clawson Co. is offering a new line of slitter-rewinders for converting operations, to be manufactured by the Dilts Machine Works Div., Fulton, N. Y.

B-C is to supply all the major board-making equipment for the U. S. Gypsum Co.'s new mill at Houston, Tex.

The Dilts Machine Works Division has expanded the facilities of its converting laboratory at Fulton, N. Y. An S. D. Warren air doctor for 18-in. webs has been installed as well as a new hot oil system manufactured by Youngstown Miller Corp., a set of chilled cast-iron rolls ground to maintain a



New Black-Clawson slitter rewinder

constant gap at elevated temperatures, and other facilities. Bulletin DLF-1005 describes the Dilts coating and converting laboratory.

J. O. Ross

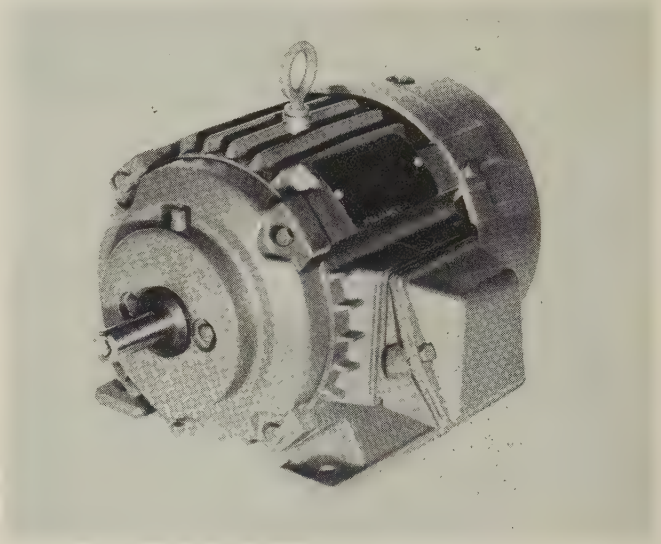
Paul Goldner has joined the sales engineering staff of J. O. Ross Engineering Corp., New York, N. Y.

The company's Boston office has moved to larger quarters at the same address, 79 Milk St., Boston 9, Mass. Elliot Patten is now in the drawing room, Harry James has moved into sales, and Pete Bouyoukas is in charge of purchasing.

Following the first of the new type Ross-Hooper totally enclosed hoods to go into operation in the U.S.A., at Great Northern Paper Co., in Maine, two Southern mills have placed orders for these new type hoods. Work is proceeding on the installation of Ross-Hooper enclosed hoods for Crossett Paper Mills, Crossett, Ark., and Sonoco Products Co., Hartsville, S. C. The new type hood for Sonoco's no. 8 machine will replace the present standard type hood while Crossett's new enclosed hood is being installed on their new cylinder board machine.

Reliance

Richard A. Gender has been appointed assistant general sales manager of Reliance Electric and Engineering Co., Cleveland, Ohio. Edward E. Helm, the company's sales vice-president has been assigned the added duties of coordinator in merging the recently acquired Reeves Pulley Co. Division with the other Reliance Division. Frank B. Carr has been named resident coordinator at the Reeves plant in Columbus, Ind.

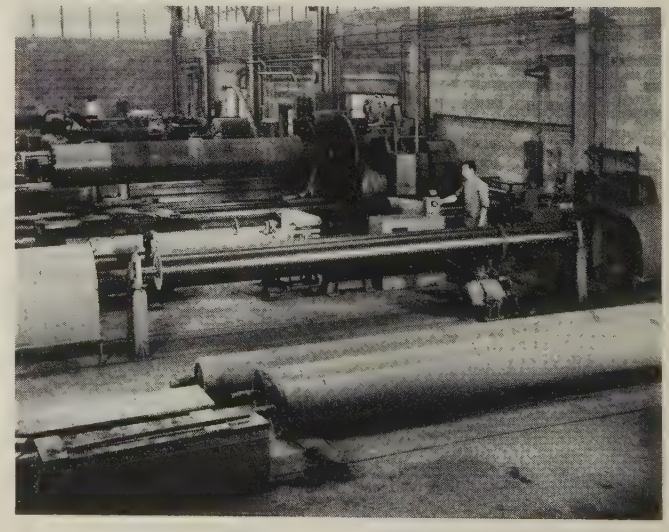


New Reliance corrosionproof motor

Reliance has developed a new corrosionproof a.c. motor qualifying for use in all Class 1, Group D, and Class 2, Groups E, F, and G classifications. The new motor is described in a Reliance pamphlet (B-2402), "From Naphtha to Grain Dust."

Raybestos-Manhattan

The Manhattan Rubber Division of Raybestos-Manhattan, Inc., Passaic, N. J., has installed a new huge two-wheel



New roll grinder at the Raybestos-Manhattan plant in Neenah, Wis.

grinder at its new plant in Neenah, Wis. The new machine is especially designed to grind calender rolls of chilled iron, steel, brass, gunmetal, chromium, granite, and wood.

Philadelphia Quartz

Albert S. Landers has been appointed to the sales service staff of Philadelphia Quartz Co., Philadelphia, Pa.

L. M. Sutherland, Sutherland Refiner Corp.

D. M. Sutherland, Sutherland Refiner Corp.

SUTHERLAND

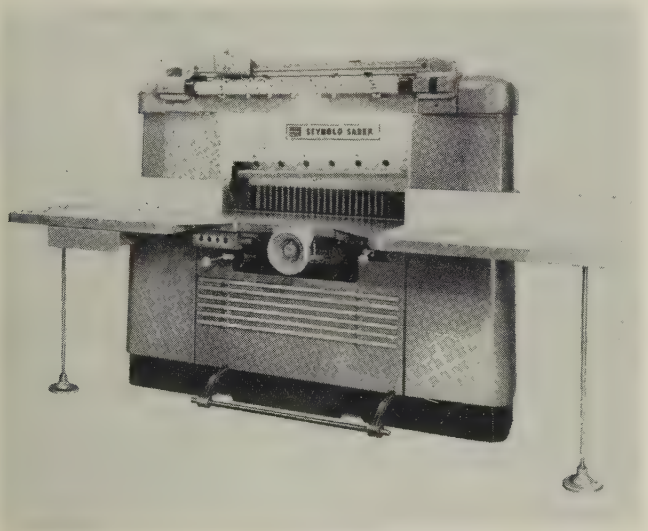
Lionel M. Sutherland has been appointed president and director of Sutherland Refiner Corp., Trenton, N. J., succeeding his father, D. Manson Sutherland, Jr., who has retired to devote more time to his overseas interests. Douglas Sutherland has been appointed vice-president and treasurer of the company, and Edna N. Barker becomes secretary.

DOWELL

Dowell, Inc., P. O. Box 536, Tulsa 1, Okla., has published a pamphlet on the company's acidizing service for water wells.

HARRIS-SEYBOLD

Harris-Seybold Co., Cleveland, Ohio, is offering a new line



One of the new Seybold Saber power paper cutters

of power paper cutters—nine models in the new sizes of 41, 47, and 54 in.—named the Saber line.

WESTINGHOUSE

Westinghouse Electric Corp., Pittsburgh, Pa., has developed an ultra-reliable control system with no moving parts, which directs the operation of complex machinery. A new department of the company will engineer, build, and sell the director systems under L. W. Golden, manager.

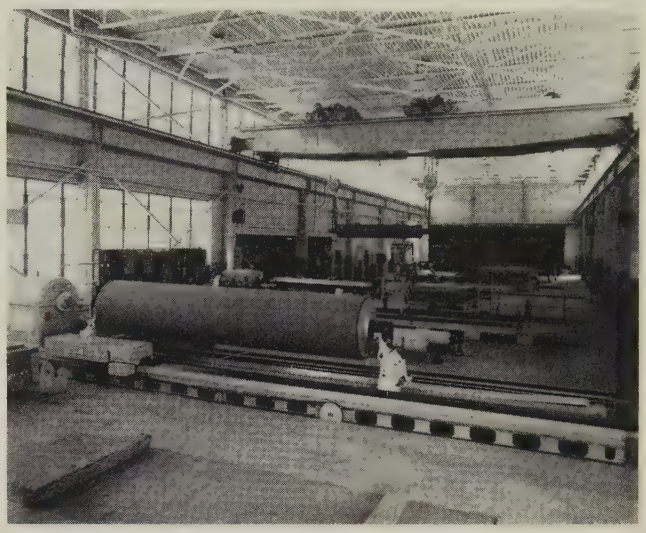
Westinghouse has issued a booklet (B-6506) explaining the advantages of Thermalastic insulation for generators, synchronous condensers, frequency changers, large motors, and other heavy rotating equipment in hard service.

LINDSAY

The Lindsay Wire Weaving Co., Cleveland, Ohio, has purchased a 35-acre site in Mentor, Ohio, 20 miles from Cleveland, on which the Austin Co. will erect a 45,000-sq. ft. plant to supplement present full-scale production at Lindsay's two plants on East 140th Street, Cleveland. At least 20 wire-weaving looms, built by Lindsay's own force, will be accommodated. Lindsay's entire output goes to manufacturers of paper.

STOWE-WOODWARD

Stowe-Woodward, Inc., Newton Upper Falls, Mass., has



The "big bay" at Stowe-Woodward's new Griffin, Ga., plant dedicated with an open house celebration May 4th. The rubber covered roll in the New Farrel grinder shown in the foreground is a bottom press roll being recovered for International Paper Co.'s Southern Kraft Div., Natchez, Miss.

formally dedicated its new roll-covering plant at New Griffin, Ga.

CYANAMID

Neil B. Conley has been appointed director of sales of the Organic Chemicals Division, American Cyanamid Co., New York, N. Y.

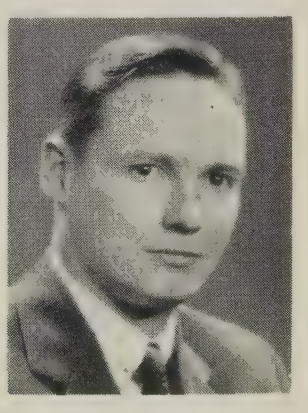
B & W

L. S. Wilcoxson has been appointed vice-president in charge of the Boiler Division of Babcock & Wilcox, New York, N. Y.

ALBANY FELT

Edmund C. Paca has been appointed sales engineer for Albany Felt Co., Albany, N. Y., covering the south central area. Ray Dustrude is now assistant sales manager, with headquarters in Albany.

L. S. Wilcoxson, Babcock & Wilcox Co.



E. C. Paca, Albany Felt Co.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Pulp Testing Committee Meeting

The meeting of the TAPPI Pulp Testing Committee (Western Section) was called to order at 9:45 a.m. March 4, 1955, at the Monte Cristo Hotel in Everett, Wash., by Chairman Frank Caskey. In attendance were: A. M. Cadigan, Elmer Christoferson, W. F. Cyrus, A. Graef, Norval Magnusson, and O. H. Sangder.

Chairman Frank Caskey reported on the Pulp Testing Committee meeting held in New York, Feb. 21, 1955, at the National TAPPI Meeting. He announced that Herb Smith has agreed to be chairman of the Eastern Section. It has been the desire of the Eastern Section to become more active and it is felt that Herb Smith will do a good job in accomplishing this. One of the main announcements concerned the future pulp testing conferences. The themes for the testing conference of 1956 will be "Precision of Testing" and for 1957 will be "Pulp Testing." Chairman Caskey indicated that the 1957 theme will be of particular interest to our committee activities.

A review was made of the activities of the Western Section. In particular, discussions were made upon the organization of the committee, the method for dirt in pulp evaluation, laboratory beater tests, and the reference pulp program.

Al Graef and Frank Caskey brought the committee up to date on the reference pulp program. The pulp is to be obtained from Weyerhaeuser at $136 per ton and is to be packaged by Everett Pulp & Paper for $0.75 per 5-lb. package or $300 per ton. The selling price of the pulp samples has been set tentatively at $5.00 a package. Mr. Nadleman of Western Michigan College has offered to handle the storing and distribution of the pulp and the opinion of the committee was that his offer should be accepted. Al Graef suggested that for the purpose of getting the program under way, all the committee members should have their laboratories run periodic tests on the pulp. It was suggested a form be enclosed in each sample for sending in the user's test results. Then all users sending in the form are to obtain a summary of the tests run on the pulp to date. Al Graef will work up the form to be used. Discussion of the tests to be reported was held; beater strength and G.E. brightness tests were thought to be of most interest. Frank Caskey is to write to J. P. Casey, division chairman, outlining the project and requesting finances.

Elmer Christoferson led discussion of dirt in pulp evaluation. Various methods of attack for studying dirt evaluation in pulp were discussed and it was finally thought best to start over and go to the pulp consumers for their ideas and methods in evaluating dirt. Elmer Christoferson is to work up a form letter to the paper mills for their comments and send a copy to Mr. Macdonald for publication in Letters to the Editor.

Norval Magnusson discussed briefly a service report from Sweden which described experiments using Valley beater and various finenesses of carborundum.

Corrugated Containers Committee

Personnel of the Corrugated Containers Committee is now as shown below:

Steering Committee

H. T. Scordas, *Chairman,* Union Bag & Paper Co., P.O. Box 570, Savannah, Ga.
John Fuko, *Secretary,* River Basin Paper Co., Monroe, Mich.
W. D. Arbuthnot, Robert Gair Co., Inc., 3200 Williamsburg Ave., Richmond 6, Va.
L. Burnett, Ohio Boxboard Co., Rittman, Ohio
E. G. Heslop, Abitibi Power & Paper Co. Ltd., Sturgen Fall, Ont.
R. L. Jenk, Mead Corp., Chillicothe, Ohio
J. J. Koenig, Gaylord Container Corp., 143 Arsenal St., St. Louis, Mo.
I. Lichtenstein, Structural Paper Co., 145 Hudson St., New York 13, N. Y.
F. D. Long, Container Corp. of America, 120 N. Clark St., Chicago 2, Ill.
K. Martin, Fort Wayne Corrugated Paper Co., Fort Wayne, Ind.
B. Mendlin, Cornell Paper Board Pro. Co., 1514 E. Thomas Ave., Milwaukee 1, Wis.
T. C. West, Hoerner Corp., Fort Worth, Tex.

Combining Subcommittee

J. J. Koenig, *Chairman,* Gaylord Container Corp., 143 Arsenal St., St. Louis, Mo.
H. T. Scordas, Union Bag & Paper Corp., P.O. Box 570, Savannah, Ga.
W. P. Blamire, American Box Board Co., Grand Rapids 2, Mich.

Finishing Subcommittee

D. Arbuthnot, *Chairman,* Fibre Board Container Corp., 3200 Williamsburg Ave., Richmond 6, Va.
T. C. West, Hoerner Corp., Southwest Corrugated Box Co., Fort Worth, Tex.
John Fuko, River Raisin Paper Co., Monroe, Mich.

Printing Subcommittee

K. Martin, *Chairman,* Fort Wayne Corrugated Paper Co., 1240 Mt. Read Blvd., Rochester, N. Y.
G. C. Lecky, F. S. Kress Box Co., 1—28th St., Pittsburgh 22, Pa.
M. L. Block, Stone Container Corp., 4200 W. 42nd St., Chicago, Ill.
C. P. Krebs, Atlas Boxmakers, 5025 W. 65th St., Chicago, Ill.
R. W. Buttery, Kraft Containers Ltd., Hamilton, Ont.

Waste Subcommittee

F. D. Long, *Chairman,* Container Corp. of America, 10 N. Clark St., Chicago 2, Ill.

A meeting of the Steering Committee was held at the Commodore Hotel, New York, N. Y., Feb. 21, 1955.

The chairman, Burt Mendlin, was not present, consequently the meeting was called to order by the secretary, John Fuko.

The first order of business was the election of officers. H. T. Scordas was elected chairman and John Fuko was continued as secretary.

The committee expressed unanimous desire to go on record in expressing their sincere thanks to Burt Mendlin for his sincere, capable, and untiring efforts on behalf of committee activities.

The advisability of appointing a vice-chairman was briefly discussed but no specific action was taken.

C. Jakeway and D. McNelly officially resigned. Three new members joined the committee. They are E. G. Heslop, R. L. Jenk, and I. Lichtenstein. Mr. Scordas welcomed them to join in committee activities and expressed his belief that their membership would be mutually gratifying.

Mr. Scordas suggested that an effort be made to increase the Steering Committee membership. Each member is requested to recruit a new candidate for membership.

A letter from E. B. Seeger of Langston expressing a desire to standardize on print cylinders, was read. The committee

felt, in general, that the idea was commendable. However, no official recommendation was made. Mr. Scordas stated that he would reply to Mr. Seeger's letter.

The secretary read a report on "Creaser Contour Design" submitted by Burt Mendlin. It is hoped that Mr. Mendlin will follow through on this project and recommend further action.

Mr. Koenig was appointed subcommittee chairman of a project aimed at ascertaining (1) optimum glue roll speeds and (2) optimum corrugating roll crowns. Mr. Koenig will select his subcommittee members and determine the feasibility, magnitude, and probable benefits of this project.

There was some discussion about combining some of the subcommittees. The details of this were somewhat nebulous. Perhaps this can be thrashed out in detail at the next meeting.

It was suggested that when the new subcommittees become established that the subcommittee chairman issue a semi-annual progress report.

The status of the combiner questionnaire is to be clarified at the next meeting.

Ked Martin was appointed program chairman of the TAPPI Corrugated Containers Fall program which will be held in Chicago, Oct. 5–7 at the Morrison Hotel. Each member was requested to submit his program ideas to Mr. Martin. He will summarize them for committee discussion.

The secretary was requested to send each member a copy of the TAPPI Corrugated Containers Committee Policy Outline." Also a copy of the "General Program," "Chairman Duties," and "Moderator Duties."

Joe Koenig was appointed general program chairman for the February, 1956, program. Any suggestions pertaining to topics for this meeting should be sent directly to Mr. Koenig.

The secretary was requested to contact National TAPPI to ascertain advisability of starting a perpetual file of committee minutes. This would make the minutes readily available to any member at any time.

JOHN FUKO, *Secretary*

TAPPI-PI Materials Testing Committee

The joint TAPPI-Packaging Institute Materials Testing Committee met on Feb. 21, 1955, at the 40th Annual Meeting of TAPPI in New York. Thirteen committee members were present from a total membership of 24, and the total attendance was 24.

Change of Committee Officers. William H. Aiken, retiring committee chairman, announced the results of the committee election of officers. T. E. Dobbins was elected chairman, P. K. Wolper, vice-chairman, and C. M. Woodcock, secretary. The new officers assumed their offices at the start of this meeting.

Discussion of Active Projects. No. 387. Water Vapor Permeability at 100°F. and 90% Relative Humidity, T 464 m-45. T. E. Dobbins, subcommittee chairman, distributed copies of the revised method, based on the adoption of the General Foods cabinet. A discussion of this method followed and several changes in the proposed revision were suggested. A final revised copy of this procedure will be distributed to the subcommittee, following which a round-robin test will be conducted on five barrier materials exhibiting a range of water vapor transmission rates. Specimens of these materials will be submitted to the subcommittee and also to a number of other individuals who have volunteered to participate in this round-robin test.

Creasing of Sheet Materials for Water Vapor Permeability Testing, T 465 sm-52. C. A. Southwick led a discussion of the problems involved in the use of the present standard procedure, which is a static test, and cited the advantages of a dynamic test. Several methods of creasing samples now being used in industry which depart from the present method were considered and these were thought to have considerable merit. A subcommittee consisting of L. F. Swec, chairman, R. L. Knarr, C. A. Southwick, P. K. Wolper, and C. M. Woodcock was appointed to follow this project.

No. 357. Water Vapor Permeability of Completed Packages. C. M. Woodcock, subcommittee chairman, has submitted final drafts of two procedures which will be used to measure the water vapor transmission rates of packages. In one of these, calcium chloride is used and, in the other, the product to be packaged is employed. These procedures have been submitted to the committee for vote and about two thirds of the ballots had been returned at the time of this meeting. If approved by the required three fourths of the committee, these methods will be forwarded to the divisional chairman and the Standards Committee.

No. 388. The Insect Resistance of Packages, Paper, and Paperboard, T 473 m-47. H. S. Gardner, subcommittee chairman, and D. G. Edwards were complimented for the excellent program on insect resistant packaging to be held on Thursday, February 24. The committee's thanks was expressed to the authors participating in this symposium. Mr. Gardner reported that a revision of the method for determining the insect resistance of packages and paper was in preparation.

No 328. Odor Transfer Through Packaging Materials. The suggested method prepared by A. H. Landrock and his subcommittee, after approval by committee ballot, was submitted to the Standards Committee of TAPPI. Several changes were suggested by the Standards Committee and the procedure has been returned to Mr. Landrock for his review.

Gas Permeability of Sheet Materials. Mr. Landrock also heads up this subcommittee and, in his absence, no report on this project was made.

Discussion of Inactive Projects. (a) No. 331—Heat Stability of Packaging Materials; (b) Rough Handling of Completed Packages; (c) Water Vapor Permeability Under Cycling Conditions. These subjects were discussed in some detail and it was agreed that any of these projects would be readily sponsored by the committee if sufficient interest was shown by volunteers who would take the position of subcommittee chairmen and members to pursue this work.

Plans for Future Committee Meetings. A committee meeting will be held at the Testing Division meeting at the Sheraton-Kimball Hotel, Springfield, Mass., Sept. 28–30, 1955.

Paperboard Testing Committee

Personnel of the Paperboard Testing Committee is as follows: Myron W. Block, *Chairman,* F. E. Field, *Vice-Chairman,* W. E. Watson, *Secretary,* William H. Aiken, Lewis K. Burnett, Robert T. Hart, C. E. Jakeway, A. T. Luey, Joseph J. Schwenkler, H. W. Verseput, and C. J. Wynstra.

Steering Subcommittee: F. E. Field, *Chairman,* C. E. Jakeway, and C. J. Wynstra.

Creasability of Paperboard Subcommittee: Robert T. Hart, Joseph J. Schwenkler, Stanley W. Trosset, Jr., and H. W. Verseput.

Ply-bond Testing Subcommittee: Lewis K. Burnett, *Chairman.*

A meeting of the committee was held at the Commodore Hotel, New York, N. Y., Feb. 21, 1955.

The meeting was called to order by the chairman, Myron W. Block, at 2:05 p.m. He suggested that attention first be directed toward defining the scope of the committee's activities.

Mr. Galbraith suggested that the proposed name "Boxboard Testing Committee" seemed to limit the activities of the committee to an unnecessarily narrow field, inasmuch as there is a great amount of board tonnage which does not go into the manufacture of boxes, but would be susceptible to the same testing procedures. He suggested that the existing

TAPPI Standards be reviewed with the purpose of making such modifications as necessary to make them suitable for the testing of boards.

After some discussion, the committee voted that it would attempt to serve the entire paperboard industry and that the name would accordingly be changed to "Paperboard Testing Committee."

In the discussion as to what materials would be considered as coming under the scope of this committee, it became apparent that we should avoid conflicting with the activities of the Structural Fibrous Materials Committee and the Corrugated Containers Committee. As a tentative arrangement, it was suggested that "paperboard" for the purpose of this committee, be considered to include such materials from 0.009 in. caliper and above, except for such thinner materials as are obviously more closely related to the board industry, but not to include containerboards. Mr. Block was to clear this matter with the other committee chairman of the Testing Division. (At the chairmen's meeting, he was informed that exact definition of our scope was not as urgent as a prompt start on worth-while projects. The feeling was that we should not include structural fibrous materials or corrugated container materials.)

Mr. Burnett outlined the conditions under which TAPPI will finance research projects.

It was pointed out that the Folding Paper Box Association is currently sponsoring a project on printability of boxboard and the Boxboard Research and Development Association is sponsoring research on a method of testing bending characteristics of board, and that this group should look into other fields.

Mr. Aiken suggested the desirability of a suitable test for the effectiveness of a score, i.e., measuring the stiffness of scored board and the efficiency of prebreaking. The possibility that this might conflict with the activities of the Packaging Materials Committee will be looked into by Mr. Block. (Mr. Block was told that this test comes under this committee's jurisdiction.)

All present agreed on the desirability of a TAPPI Standard on the stiffness of paperboard. Mr. Aiken was appointed to head a subcommittee to draw up such a tentative standard. He will organize a round robin testing program to evaluate the reproducibility of the method.

The following subcommittee was appointed to assemble information on existing methods for testing creasibility of paperboard: R. T. Hart, J. J. Schwenkler, S. W. Trosset, and H. W. Verseput.

The following subcommittee was appointed to review the present TAPPI Standards and choose those which should be revised for application to board: F. E. Field, *Chairman*, C. E. Jakeway, and C. J. Wynstra.

In view of the work Ohio Boxboard has done on ply-bond testing, Mr. Burnett was asked to prepare a review of this field and agreed to do so.

It was agreed to adopt a succession of officers, so that each year the vice-chairman advances to chairman, the secretary becomes vice-chairman, and a new secretary is chosen.

The possibility of participating in the next testing conference was considered. This conference will be held in Springfield, Mass., in September of this year. Each of our subcommittees is requested to present a paper at this time. Also, there will be held in Chicago in 1956 a conference on the testing of packages and packaging materials, in which we will be expected to take an active part.

Our new name has met with approval of the remainder of the Testing Division.

H. W. Verseput, *Acting Secretary*

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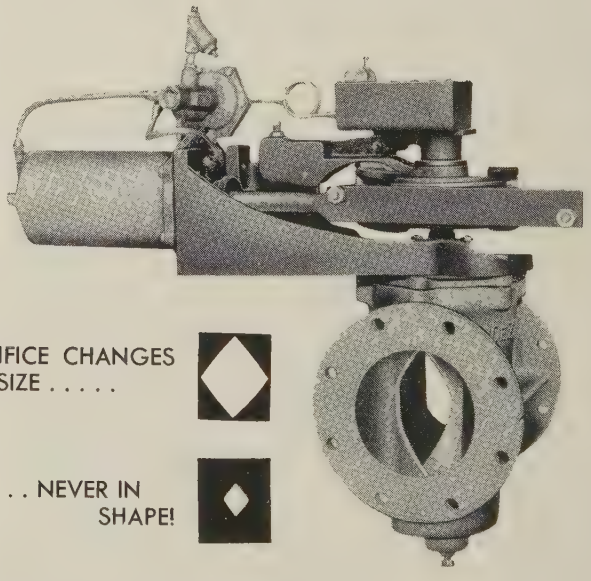

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TAPPI Fibrary

Second Edition

This catalog is an alphabetical composite of those previously published for the TAPPI Fibrary, for which collection efforts were initiated in October, 1949. Although 390 samples are listed to date there are still many fibers which are needed. It is hoped that contributions of missing species will be forthcoming from TAPPI members so this fiber collection may continue to enlarge and increase in value. Addenda to this index will be published as occasion requires.

A representative specimen of each fiber may be obtained from the Fibrary, The Institute of Paper Chemistry, Appleton, Wis. Each sample has a number which may be used in ordering. A service charge of 25 cents ($0.25) per sample has been established to help defray the cost of handling, packing, and postage. Remittance of the necessary fee at the time of ordering will help to keep these costs as low as possible.

The custodians of the Fibrary have checked, to the best of their ability, all fibers submitted, as to species and process. Please write us if any error is detected.

The amount of pulping data given by the donor varies considerably in different samples. Because of space limitations many of the details which have been sent with the sample will not be published but will be filed with the sample for reference purposes. Naturally, it is desirable to have complete details, if available.

No acknowledgment has been made in the catalog to the donors for the various samples. In many instances several companies or individuals offered the same fibers and while duplication is inevitable, every effort was made to avoid it to conserve space without decreasing the effectiveness of the fiber collection. Unquestionably, the gratitude of the industry is due these anonymous donors.

Fibrary

No.	*Species*	*Location grown*	*Process*	*Degree of cooking*	*Bleaching*	*Remarks*
195	Acacia, bullhorn (*Acacia auricularis*)	Florida	Kraft	Medium	None	....
196	Alder, red (*Alnus rubra*)	British Columbia	Sulphite	Medium	None	Laboratory screened
197	Alder, red (*Alnus rubra*)	Oregon	Neutral sulphite semichemical	Intermediate yield	None	....
1	Ambari hemp (*Hibiscus cannabinus*)	India	Soda	Soft	None	....
2	*Arundo donax* reed	Texas	Kraft	Soft	None	....
45	Ash, mountain (*Eucalyptus regnans*)	Australia	Groundwood	....	None	Mixture with 5% *E. gigantea* and 5% *E. obliqua*
198	Ash, mountain (*Eucalyptus regnans*)	Australia	Kraft	Medium	None	....
199	Ash, mountain (*Eucalyptus regnans*)	Australia	Kraft	Medium	None	Sapwood
200	Ash, mountain (*Eucalyptus regnans*)	Australia	Kraft	Medium	None	Heartwood
201	Aspen, European (*Populus tremula*)	Sweden	Sulphite	....	Full	....
3	Aspen (*Populus tremuloides*)	Wisconsin and Michigan	Groundwood	....	None	....
4	Aspen (*Populus tremuloides*)	Minnesota	Groundwood	....	Full	Peroxide bleached
360	Aspen (*Populus tremuloides*)	Michigan	Groundwood	....	Full	Hypochlorite bleached
202	Aspen (*Populus tremuloides*)	New York	Chemigroundwood	....	None	....
361	Aspen (*Populus tremuloides*)	Michigan	Sulphite	Medium	None	....
362	Aspen (*Populus tremuloides*)	Michigan	Sulphite	Medium	Full	....
5	Aspen (*Populus tremuloides*)	Wisconsin and Michigan	Neutral sulphite	....	None	Bauer refiner
6	Aspen (*Populus tremuloides*)	Wisconsin and Michigan	Neutral sulphite	....	Semi	Same pulp as previous; single stage calcium hypochlorite bleach
7	Aspen (*Populus tremuloides*)	Minnesota	Neutral sulphite	....	None	Asplund defibrator; sodium sulphite and caustic soda
8	Aspen (*Populus tremuloides*)	Minnesota	Neutral sulphite	....	None	Given additional refining over previous sample
9	Aspen (*Populus tremuloides*)	Minnesota	Kraft	Soft	None	....
10	Aspen (*Populus tremuloides*)	Minnesota	Kraft	Soft	Full	....
203	Aspen (*Populus tremuloides*)	Michigan	Kraft semichemical	High yield	None	....
204	Aspen (*Populus tremuloides*)	Michigan	Kraft (Asplund)	....	None	....
	Bagasse—*see* Sugarcane bagasse.					
11	Balm-of-Gilead (*Populus balsamifera*)	Ontario	Kraft	Soft	None	....
205	Bamboo (*Bambusa arundinacea*)	Australia	Kraft	Hard	None	....
206	Bamboo (Daba or Kanta) (*Bambusa arundinacea*)	India	Sulphite	Soft	None	Magnesia base
207	Bamboo (Daba or Kanta) (*Bambusa arundinacea*)	India	Sulphite	Soft	Semi	Magnesia base
208	Bamboo (Daba or Kanta) (*Bambusa arundinacea*)	India	Sulphite	Soft	Full	Magnesia base
209	Bamboo (Balki or Baluki) (*Bambusa balcooa*)	India	Sulphite	Soft	None	Magnesia base
210	Bamboo (Balki or Baluki) (*Bambusa balcooa*)	India	Sulphite	Soft	Semi	Magnesia base
211	Bamboo (Balki or Baluki) (*Bambusa balcooa*)	India	Sulphite	Soft	Full	Magnesia base
212	Bamboo (Salia) (*Dendrocalamus strictus*)	India	Sulphite	Soft	None	Magnesia base

No.	Species	Location grown	Process	Degree of cooking	Bleaching	Remarks
213	Bamboo (Salia) (*Dendrocalamus strictus*)	India	Sulphite	Soft	Semi	Magnesia base
214	Bamboo (Salia) (*Dendrocalamus strictus*)	India	Sulphite	Soft	Full	Magnesia base
215	Bamboo (Muli or Mitenga) (*Melocanna bambusoides*)	India	Sulphite	Soft	None	Magnesia base
216	Bamboo (Muli or Mitenga) (*Melocanna bambusoides*)	India	Sulphite	Soft	Semi	Magnesia base
217	Bamboo (Muli or Mitenga) (*Melocanna bambusoides*)	India	Sulphite	Soft	Full	Magnesia base
218	Barley straw (*Hordeum vulgare*)	Holland	Lime semichemical	....	None	....
12	Barley straw (*Hordeum vulgare*)	Holland	Alkaline sulphite	....	None	Sodium sulphite caustic soda
363	Basswood (*Tilia americana*)	Wisconsin	Sulphite	Medium	None	....
364	Basswood (*Tilia americana*)	Wisconsin	Sulphite	Medium	Full	....
365	Basswood (*Tilia americana*)	Wisconsin	Neutral sulphite semichemical	Intermediate yield	None	....
366	Basswood (*Tilia americana*)	Wisconsin	Neutral sulphite semichemical	Intermediate yield	Full	Three-stage bleach
13	Beech, European (*Fagus sylvatica*)	France	Acid semichemical	....	None	ABI Process
14	Beech, European (*Fagus sylvatica*)	France	Acid semichemical	....	Full	ABI Process
15	Beech, European (*Fagus sylvatica*)	Yugoslavia	Sulphite	20° Sieber	Full	....
16	Beech, European (*Fagus sylvatica*)	Yugoslavia	Sulphite	20° Sieber	Full	Nobilized
17	Birch, European white (*Betula alba*)	Sweden	Kraft	Medium	Full	....
219	Birch, paper (*Betula papyrifera*)	Wisconsin	Sulphite	Soft	None	Mitscherlich
220	Birch, paper (*Betula papyrifera*)	Wisconsin	Sulphite	Medium	Full	Mitscherlich
221	Birch, paper (*Betula papyrifera*)	Wisconsin	Kraft	Soft	None	....
222	Birch, paper (*Betula papyrifera*)	Wisconsin	Kraft	Soft	Full	Three-stage bleach
223	Birch, paper (*Betula papyrifera*)	Wisconsin	Neutral sulphite semichemical	60% yield	None	....
224	Birch, paper (*Betula papyrifera*)	Wisconsin	Neutral sulphite semichemical	73% yield	None	....
225	Birch, paper (*Betula papyrifera*)	Wisconsin	Neutral sulphite semichemical	73% yield	Full	Three-stage bleach
226	Birch, Swedish	Sweden	Sulphite	....	Full	....
18	Birch, Swedish (*Betula verrucosa pubescens*)	Sweden	Kraft	Medium	Full	Final stage bleach with chlorine dioxide
227	Birch, yellow (*Betula lutea*)	New York	Chemigroundwood	....	None	....
228	Black-mangrove (*Avicennia nitida*)	Florida	Kraft	Soft	None	....
229	Blady grass (*Imperata cylindrica*)	New Guinea	Soda	Medium	None	....
230	Butterbough (*Exothea paniculata*)	Florida	Kraft	Soft	None	....
231	Buttonbush, common (*Cephalanthus occidentalis*)	Florida	Kraft	Soft	None	....
232	Button-mangrove (*Conocarpus erecta*)	Florida	Kraft	Hard	None	....
19	Cantala fiber (*Agave cantala*)	Java	Soda	Soft	None	....
20	Caroa fiber (*Neoglaziovia variegata*)	Brazil	Soda	Soft	None	....
367	Cherry, black (*Prunus serotina*)	Wisconsin	Sulphite	Hard	None	High screenings
368	Cherry, black (*Prunus serotina*)	Wisconsin	Sulphite	Hard	Full	28% yield
369	Cherry, black (*Prunus serotina*)	Wisconsin	Neutral sulphite semichemical	Intermediate yield	None	....
370	Cherry, black (*Prunus serotina*)	Wisconsin	Neutral sulphite semichemical	Intermediate yield	Full	Three-stage bleach
21	Chestnut, Spanish (*Castanea sativa*)	France	Soda	Medium	Full	....
22	Chestnut, Spanish (*Castanea sativa*)	Italy	Kraft	3.0 Roe	None	Extracted chips
233	Chinkapin, Ashe (*Castanea ashei*)	North Carolina	Kraft	Soft	None	....
234	*Coelorachis rottboellioides*	New Guinea	Soda	Medium	None	Grass
23	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	....	..	Nitration type
24	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	....	..	Acetate plastics
25	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	....	..	Viscose
26	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	....	..	Writing papers, etc.
27	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	....	..	Viscose, sheet
28	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	....	..	Cellulose ethers
29	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	Soft	Full	Second cut and mill run linters
30	Cotton seed hair (*Gossypium hirsutum*)	United States	Soda	Soft	Full	Unbleached muslin cuttings
31	Cotton stalk (*Gossypium hirsutum*)	United States	....	....	None	....
32	Cotton stalk (*Gossypium hirsutum*)	United States	....	....	Semi	....
235	Cottonwood, northern black (*Populus Trichocarpa* var. *hastata*)	British Columbia	Sulphite	Medium	None	Laboratory screened
236	Cypress pine, black (*Callitris calcarata*)	Australia	Kraft	Medium	None	....
237	Cyrilla, American (*Cyrilla racemiflora*)	Florida	Kraft	Soft	None	....
238	Damanu (*Calophyllum* sp.)	Fiji	Kraft	Medium	None	....
239	Darling-plum (*Reynosia septentrionalis*)	Florida	Kraft	Medium	None	....
371	Date palm leaf (*Phoenix dactylifera*)	Iraq	Neutral sulphite semichemical	45% yield	None	....
240	Davota (*Calophyllum* sp.)	Fiji	Kraft	Medium	None	....
33	Douglas-fir (*Pseudotsuga taxifolia*)	Oregon	Asplund	....	None	Hardboard pulp
34	Douglas-fir (*Pseudotsuga taxifolia*)	Oregon	Asplund	....	None	Bauer refined; hardboard pulp
35	Douglas-fir (*Pseudotsuga taxifolia*)	Pacific Northwest	Soda	Soft	None	....
36	Douglas-fir (*Pseudotsuga taxifolia*)	Oregon	Kraft	Soft	None	....
37	Douglas-fir (*Pseudotsuga taxifolia*)	Oregon	Kraft	Soft	Semi	....

No.	Species	Location grown	Process	Degree of cooking	Bleaching	Remarks
38	Douglas-fir (*Pseudotsuga taxifolia*)	Pacific Northwest	Kraft	Medium	None	....
39	Douglas-fir (*Pseudotsuga taxifolia*)	Pacific Northwest	Sulphite	Semichemical	Full	....
40	Douglas-fir (*Pseudotsuga taxifolia*)	Pacific Northwest	Sulphite	Hard	None	Ammonia base
241	Dove-plum (*Coccolobis laurifolia*)	Florida	Kraft	Soft	None	....
41	Elephant grass (or bango reed)	South Africa	....	....	..	....
42	Esparto (*Stipa tenacissima*)	Algeria	Soda	Medium	None	....
43	Esparto (*Stipa tenacissima*)	Algeria	Soda	Medium	Full	Sodium hypochlorite bleach
242	Eugenia, redberry (*Eugenia confusa*)	Florida	Kraft	Soft	None	....
243	Eugenia, spiceberry (*Eugenia rhombea*)	Florida	Kraft	Soft	None	..
244	Eugenia, white-stopper (*Eugenia axillaris*)	Florida	Kraft	Soft	None	....
245	False-mangrove (*Laguncularia racemosa*)	Florida	Kraft	Soft	None	....
246	False-mastic (*Sideroxylon foetidissimum*)	Florida	Kraft	Soft	None	....
247	Farkleberry tree (*Vaccinium arboreum*)	North Carolina	Kraft	Soft	None	....
46	Fique fiber (*Fourcroya macrophylla*)	....	Soda	Soft	None	....
47	Fir, balsam (*Abies balsamea*)	Quebec	Groundwood	....	None	....
48	Fir, balsam (*Abies balsamea*)	Minnesota	Groundwood	....	Full	Peroxide bleached
49	Fir, balsam (*Abies balsamea*)	Ontario	Sulphite	Medium	None	....
50	Fir, balsam (*Abies balsamea*)	Ontario	Sulphite	Medium	Full	
51	Fir, balsam (*Abies balsamea*)	Wisconsin and Minnesota	Kraft	Medium	None	....
248	Fir, grand (*Abies grandis*)	British Columbia	Sulphite	Medium	None	Laboratory screened
52	Fir, red (*Abies magnifica*)	California	Kraft	Soft	None	....
53	Fir, silver (*Abies alba*)	Germany	Groundwood	....	..	....
54	Fir, silver (*Abies alba*)	France	Neutral sulphite	....	None	Mixed with Norway spruce; sawmill slabs, including some bark
55	Fir, western balsam (*Abies* sp.)	British Columbia	Sulphite	Soft	None	....
56	Fir, western balsam (*Abies* sp.)	British Columbia	Sulphite	Soft	Semi	....
57	Fir, western balsam (*Abies* sp.)	British Columbia	Sulphite	Soft	Full	....
58	Fir, white (*Abies concolor*)	California	Kraft	Hard	None	....
249	Fir, white (*Abies concolor*)	California	Kraft	Soft	None	....
250	Fishfuddle tree, Florida (*Ichthyomethia communis*)	Florida	Kraft	Medium	None	....
59	Flax (*Linkum usitatissimum*)	Holland	Soda	Medium	Full	....
251	Flax (*Linum usitatissimum*)	Holland	Soda	Soft	Full	Linen; beaten
60	Flax (*Linum usitatissimum*)	Minnesota	Kraft	Medium	None	....
61	Flax shives	Minnesota	Sulphur-ammonia	....	None	....
252	Flax (*Linum usitatissimum*)	Holland	Soda	....	None	Straw from oil plants
253	Flax (*Linum usitatissimum*)	Minnesota	Soda	....	Full	Straw from oil plants
44	Gum, blue (*Eucalyptus globulus*)	California	Asplund	....	..	Roofing felts
254	Gum, mountain gray (*Eucalyptus goniocalyx*)	Australia	Kraft	Medium	None	....
255	Gum, scribbly (*Eucalyptus micrantha*)	Australia	Kraft	Medium	None	....
256	Gum, sugar (*Eucalyptus cladocalyx*)	Australia	Kraft	Medium	None	....
257	Gumbo-limbo (*Elaphrium simaruba*)	Florida	Kraft	Medium	None	....
62	Hemlock, eastern (*Tsuga canadensis*)	Nova Scotia	Sulphite	Hard	None	....
63	Hemlock, eastern (*Tsuga canadensis*)	Nova Scotia	Sulphite	Medium	None	....
64	Hemlock, western (*Tsuga heterophylla*)	Pacific Northwest	Sulphite	Medium	None	....
65	Hemlock, western (*Tsuga heterophylla*)	British Columbia	Sulphite	Soft	None	Dissolving pulp
66	Hemlock, western (*Tsuga heterophylla*)	British Columbia	Sulphite	Soft	Semi	Dissolving pulp
67	Hemlock, western (*Tsuga heterophylla*)	British Columbia	Sulphite	Soft	Full	Dissolving pulp
68	Hemlock, western (*Tsuga heterophylla*)	Pacific Northwest	Sulphite	Soft	None	Ammonia base
69	Hemlock, western (*Tsuga heterophylla*)	Pacific Northwest	Sulphite	Soft	None	Magnesium base
70	Hemlock, western (*Tsuga heterophylla*)	Alaska	Kraft	Medium	None	....
71	Hemlock, western (*Tsuga heterophylla*)	Oregon	Kraft	Medium	None	....
72	Hemlock, western (*Tsuga heterophylla*)	Oregon	Kraft	Medium	Semi	....
258	Hemp rope (*Cannabis sativa*)	....	Soda	....	None	....
73	Hemp rope	....	Soda	Medium	Full	Cooked in India, source unknown
259	Hemp rope (*Cannabis sativa*)	Spain	Soda	Soft	Full	Fishing nets
372	Hophornbeam (*Ostrya virginiana*)	Wisconsin	Sulphite	Medium	None	....
373	Hophornbeam (*Ostrya virginiana*)	Wisconsin	Sulphite	Medium	Full	....
374	Hophornbeam (*Ostrya virginiana*)	Wisconsin	Neutral sulphite semichemical	Intermediate yield	None	....
375	Hophornbeam (*Ostrya virginiana*)	Wisconsin	Neutral sulphite semichemical	Intermediate yield	Full	Three-stage bleach
260	Ilang-ilant (*Canangium odoratum*)	Philippine Islands	Kraft	Soft	None	....
261	Ilang-ilant (*Canangium odoratum*)	Philippine Islands	Kraft	Soft	Full	Three-stage bleach
262	*Imperata exaltata*	New Guinea	Soda	Medium	None	....
74	Incense-cedar (*Libocedrus decurrens*)	California	Kraft	Soft	Semi	....
263	Kauri, Fiji (*Agathis vitiensis*)	Fiji	Kraft	Medium	None	....
264	Kauri, South Queensland (*Agathis robusta*)	Australia	Kraft	Medium	None	....
265	Kauvula *Endospermum macrophyllum*)	Fiji	Kraft	Medium	None	....
75	Kozo (*Broussonetia papyrifera*)	Japan	Soda	Hard	None	....
266	Lancewood (*Nectandra coriacea*)	Florida	Kraft	Soft	None	....
267	Larch, western (*Larix occidentalis*)	Idaho	Kraft	Soft	None	....
268	Leadwood (*Krugiodendron ferreum*)	Florida	Kraft	Soft	None	....
76	*Lespedeza sericea*	Alabama	Kraft	....	None	....

No.	Species	Location grown	Process	Degree of cooking	Bleaching	Remarks
77	*Lespedeza sericea*	Alabama	Kraft	....	Full	Sodium hypochlorite bleach
78	*Lespedeza sericea*	Alabama	Pomilio	....	Full	....
269	Lignumvitae (*Guaiacum sanctum*)	Florida	Kraft	Soft	None	....
270	Loblolly-bay (*Gordonia lasianthus*)	Florida	Kraft	Soft	None	....
271	Lysiloma, Bahama (*Lysiloma bahamensis*)	Florida	Kraft	Medium	None	....
272	Mahogany, West Indies (*Swietenia mahagoni*)	Florida	Kraft	Soft	None	....
273	Mallet (*Eucalyptus occidentalis*)	Australia	Kraft	Medium	None	....
274	Mangrove, red (*Rhizophora mangle*)	Florida	Kraft	Soft	None	....
275	Manila fiber (*Musa textilis*)	....	Neutral sulphite	....	..	Reclaimed rope; cooked in U. S.
79	Manila fiber (*Musa textilis*)	Philippine Islands	Soda	Soft	None	....
80	Manila fiber (*Musa textilis*)	Philippine Islands	Alkaline sulphite	Soft	None	....
276	Maple, Carolina red (*Acer rubrum* var. *tridens*)	Florida	Kraft	Soft	None	....
376	Maple, Hard and Soft (*Acer* sp.)	Ontario	Sulphite	Medium	None	....
277	Maple, sugar (*Acer saccharum*)	New England	Kraft	Soft	None	....
278	Maple, sugar (*Acer saccharum*)	New England	Kraft	Soft	Full	....
279	Maple, sugar (*Acer saccharum*)	New England	Neutral sulphite semichemical	70% yield	None	....
280	Maple, sugar (*Acer saccharum*)	New England	Neutral sulphite semichemical	70% yield	Full	Three-stage bleach
81	Mauritius hemp (*Fourcroya gigantea*)	Mauritius	Soda	Soft	None	....
82	Mesquite (*Prosopis juliflora*)	Texas	Kraft	Medium	None	....
281	Milkbark (*Drypetes diversifolia*)	Florida	Kraft	Hard	None	....
83	Mora (*Mora excelsa*)	British Guiana	Kraft	....	None	Dye extracted before cook
84	New Zealand flax (*Phormium tenax*)	New Zealand	Kraft	Hard	None	....
85	New Zealand flax (*Phormium tenax*)	New Zealand	Neutral sulphite	Hard	None	Board grade
86	New Zealand flax (*Phormium tenax*)	Azore Islands	Alkaline sulphite	Medium	None	....
282	New Zealand flax (*Phormium tenax*)	Australia	Soda	Hard	None	....
283	Oak, bluejack (*Quercus incana*)	Florida	Kraft	Soft	None	....
87	Oak, English (*Quercus robur*)	France	Soda	Medium	Full	....
284	Oak, Laurel (*Quercus laurifolia*)	Florida	Kraft	Soft	None	....
285	Oak, live (*Quercus virginiana*)	Florida	Kraft	Soft	None	....
377	Oak, northern red (*Quercus rubra*)	Wisconsin	Sulphite	Medium	None	....
378	Oak, northern red (*Quercus rubra*)	Wisconsin	Sulphite	Medium	Full	....
379	Oak, northern red (*Quercus rubra*)	Wisconsin	Neutral sulphite semichemical	Low yield	None	....
380	Oak, northern red (*Quercus rubra*)	Wisconsin	Neutral sulphite semichemical	Low yield	Full	Three-stage bleach
286	Oak, northern red (*Quercus rubra*)	New England	Sulphite semichemical	58% yield	None	Ammonia base; unbarked
287	Oak, overcup (*Quercus lyrata*)	Florida	Kraft	Soft	None	....
288	Oak, overcup (*Quercus lyrata*)	Arkansas	Kraft	Soft	Full	....
88	Oak, post (*Quercus stellata*)	Texas	Kraft	Soft	None	....
289	Oak, sand live (*Quercus virginiana* var. *geminata*)	Florida	Kraft	Soft	None	....
291	Oak, sand post (*Quercus stellata* var. *margaretta*)	North Carolina	Kraft	Soft	None	....
290	Oak, silky (*Grevillea robusta*)	Australia	Kraft	Medium	None	....
292	Oak, southern red (*Quercus falcata*)	North Carolina	Kraft	Soft	None	....
293	Oak, swamp chestnut (*Quercus michauxii*)	Florida	Kraft	Soft	None	....
294	Oak, turkey (*Quercus laevis*)	Florida	Kraft	Soft	None	....
295	Oak, water (*Quercus nigra*)	North Carolina	Kraft	Soft	None	....
381	Oak, white (*Quercus alba*)	Wisconsin	Sulphite	Medium	None	....
382	Oak, white (*Quercus alba*)	Wisconsin	Sulphite	Medium	Full	....
296	Oak, white (*Quercus alba*)	North Carolina	Kraft	Soft	None	....
383	Oak, white (*Quercus alba*)	Wisconsin	Neutral sulphite semichemical	Low yield	None	....
384	Oak, white (*Quercus alba*)	Wisconsin	Neutral sulphite semichemical	Low yield	Full	Three-stage bleach
89	Oat straw (*Avena sativa*)	Holland	Alkaline sulphite	Soft	None	....
297	Oat straw (*Avena sativa*)	Holland	Lime semichemical	....	None	....
298	Oysterwood, shiny (*Gymnanthes lucida*)	Florida	Kraft	Hard	None	....
385	Para rubber tree (*Hevea brasiliensis*)	Liberia	Kraft	Soft	None	....
299	*Phragmites communis* reed	Holland	Soda	....	None	....
300	Pine, bishop (*Pinus muricata*)	Australia	Kraft	Medium	None	12-yr.-old trees
301	Pine, bunya (*Arucaria bidwilli*)	Australia	Kraft	Medium	None	....
90	Pine, Corsican (*Pinus laricio* var. *calabrica*)	Italy	Kraft	....	None	....
302	Pine, hoop (*Araucaria cunninghami*)	Australia	Kraft	Medium	None	....
91	Pine, jack (*Pinus banksiana*)	Minnesota	Kraft	Soft	None	....
92	Pine, jack (*Pinus banksiana*)	Minnesota	Kraft	Soft	Semi	Two-stage bleach
93	Pine, jack (*Pinus banksiana*)	Minnesota	Kraft	Soft	Full	Five-stage bleach
94	Pine, jack (*Pinus banksiana*)	Wisconsin	Kraft	Medium	None	....
95	Pine, jack (*Pinus banksiana*)	Minnesota	Sulphite	Soft	None	Sapwood
96	Pine, jack (*Pinus banksiana*)	Minnesota	Sulphite	Soft	None	Sapwood; sodium base
303	Pine, jack (*Pinus banksiana*)	Wisconsin	Neutral sulphite semichemical	High yield	None	....
97	Pine, Jeffrey (*Pinus jeffreyi*)	California	Kraft	Medium	None	....
304	Pine, loblolly (*Pinus taeda*)	Mississippi	Asplund	....	None	....

No.	Species	Location grown	Process	Degree of cooking	Bleaching	Remarks
305	Pine, loblolly (*Pinus taeda*)	Mississippi	Groundwood	....	None	....
98	Pine, loblolly (*Pinus taeda*)	Louisiana and Arkansas	Kraft	Medium	None	....
99	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	Pacific Northwest	Sulphite	Medium	None	....
100	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	Pacific Northwest	Sulphite	Soft	None	....
101	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	Pacific Northwest	Sulphite	Medium	None	Ammonia base
102	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	Pacific Northwest	Sulphite	Soft	None	Ammonia base
103	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	Pacific Northwest	Sulphite	Medium	None	Magnesium base
104	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	Pacific Northwest	Sulphite	Soft	None	Magnesium base
105	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	Montana	Kraft	Medium	None	....
106	Pine, lodgepole (*Pinus contorta* var. *latifolia*)	California	Kraft	Medium	None	....
107	Pine, longleaf (*Pinus palustris*)	Texas	Kraft	Medium	None	....
306	Pine, longleaf (*Pinus palustris*)	Florida	Kraft	Soft	None	....
108	Pine, maritime (*Pinus maritima*)	France	Sulphite	Soft	Full	....
109	Pine, maritime (*Pinus pinaster*)	Italy	Kraft	....	None	....
110	Pine, maritime (*Pinus pinaster*)	Italy	Kraft	....	None	....
111	Pine, Mexican (*Pinus montzumae*)	Mexico	Kraft	Medium	None	....
112	Pine, Monterey (*Pinus radiata*)	New Zealand	Kraft	Hard	None	Slabwood
113	Pine, Monterey (*Pinus radiata*)	New Zealand	Kraft	Medium	None	Slabwood
114	Pine, Monterey (*Pinus radiata*)	New Zealand	Kraft	Soft	None	Slabwood
115	Pine, Monterey (*Pinus radiata*)	California	Asplund	Hard	None	Roofing felts
116	Pine, Mountain (*Pinus montana*)	Italy	Kraft	....	None	....
307	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Kraft	Medium	None	8-yr.-old trees
308	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Kraft	Medium	None	Sapwood
309	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Kraft	Medium	None	Heartwood
310	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Neutral sulphite semichemical	78% yield	None	8-yr.-old trees
311	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Neutral sulphite semichemical	77% yield	None	Sapwood
312	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Neutral sulphite semichemical	75% yield	None	Heartwood
117	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Sulphite	....	None	....
313	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Sulphite	Soft	None	8-yr.-old trees
314	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Sulphite	Medium	None	Sapwood
315	Pine, Parana (*Araucaria brasiliensis*)	Brazil	Sulphite	Medium	None	Heartwood
386	Pine, ponderosa (*Pinus ponderosa*)	Washington	Kraft	Medium	None	....
118	Pine, Scotch (*Pinus silvestris*)	Sweden	Kraft	Hard	None	....
119	Pine, Scotch (*Pinus silvestris*)	Sweden	Kraft	Medium	None	....
120	Pine, Scotch (*Pinus silvestris*)	Sweden	Kraft	Medium	Full	....
121	Pine, Scotch (*Pinus silvestris*)	Sweden	Kraft	Medium	Full	Bleached with chlorine dioxide
122	Pine, Scotch (*Pinus silvestris*)	Finland	Kraft	7.7 Roe	None	....
123	Pine, Scotch (*Pinus silvestris*)	Finland	Kraft	5.5 Roe	None	....
124	Pine, Scotch (*Pinus silvestris*)	Finland	Kraft	2.6 Roe	None	....
125	Pine, Scotch (*Pinus silvestris*)	Norway	Kraft	Soft	None	Includes 20% Norway spruce
126	Pine, Scotch (*Pinus silvestris*)	Italy	Groundwood	....	None	Includes some spruce and poplar
387	Pine, shortleaf (*Pinus echinata*)	Alabama	Kraft	Soft	None	....
127	Pine, slash (*Pinus caribaea*)	Georgia	Kraft	Medium	None	....
128	Pine, slash (*Pinus caribaea*)	Georgia	Kraft	Soft	None	....
316	Pine, slash (*Pinus caribaea*)	Georgia	Kraft semichemical	Intermediate yield	None	....
317	Pine, slash (*Pinus caribaea*)	Georgia	Kraft semichemical	Intermediate yield	None	Unbarked
318	Pine, slash (*Pinus caribaea*)	Georgia	Sulphite semichemical	Intermediate yield	None	Ammonia base
319	Pine, slash (*Pinus caribaea*)	Georgia	Kraft (Asplund)	Low yield	None	....
320	Pine, slash (*Pinus caribaea*)	Georgia	Neutral sulphite (Asplund)	High yield	None	....
321	Pine, slash (*Pinus caribaea*)	Georgia	Neutral sulphite semichemical	High yield	None	Unbarked
129	Pine, sugar (*Pinus lambertiana*)	California	Kraft	Medium	None	....
130	Pine, Virginia (*Pinus virginiana*)	Maryland	Steamed and refined	....	None	Unpeeled wood; steamed in presence of water and hydrated lime, then Bauer refined
322	Pine, western white (*Pinus monticola*)	Idaho	Kraft	Soft	None	....
131	Pine, white (*Pinus strobus*)	New York	Groundwood	....	None	Wall paper grade
132	Pineapple (*Ananas comosus*)	Puerto Rico	Soda	....	..	....
323	Pita or Century plant (*Agave americana*	Spain	Soda	Soft	Full	....
133	Pita floja (*Aechme magdalenae*)	Columbia	Soda	Medium	None	....
324	Pondapple (*Annona glabra*)	Florida	Kraft	Soft	None	....
134	Poplar (*Populus* sp.)	United States	Soda	....	None	....
135	Poplar (*Populus* sp.)	United States	Soda	....	Full	One-stage bleach

No.	Species	Location grown	Process	Degree of cooking	Bleaching	Remarks
325	Poplar (*Populus* sp.)	United States	Sulphite semichemical	65% yield	None	Ammonia base
388	Poplar, balsam (*Populus balsamifera*)	Ontario	Neutral sulphite chemical	Intermediate yield	None	....
136	Poplar, Black (*Populus italica*)	Italy	Sulphite	30° Sieber	Full	Two-stage bleach
137	Poplar (*Populus canadensis*)	Italy	Sulphite	20° Sieber	Full	Nobilized
138	Poplar (*Populus canadensis*)	Italy	Sulphite	20° Sieber	Full	Heartwood
139	Poplar, white (*Populus alba*)	Italy	Groundwood	....	None	....
140	Poplar, white (*Populus alba*)	Italy	Kraft	3.0 Roe	None	....
141	Poplar, white (*Populus alba*)	Italy	Soda	....	..	....
142	Port Orford cedar (*Chamaecyparis lawsoniana*)	Oregon	Sulphite	Medium	None	....
143	Port Orford cedar (*Chamaecyparis lawsoniana*)	Oregon	Kraft	Hard	None	....
144	Ramie (*Boehmeria nivea* var. *tenacissima*)	Brazil	Kraft	Medium	None	....
326	Ramie (*Boehmeria nivea* var. *tenacissima*	....	Soda	....	None	Cooked in Holland; source unknown
327	Red-cedar, western (*Thuja plicata*)	Idaho	Kraft	Soft	None	....
145	Red-cedar, western (*Thuja plicata*)	Pacific Northwest	Sulphite	Medium	None	....
146	Red-cedar, western (*Thuja plicata*)	Pacific Northwest	Sulphite	Medium	None	Magnesium base
147	Red-cedar, western (*Thuja plicata*)	Pacific Northwest	Sulphite	Soft	None	Ammonia base
148	Rice straw (*Oryza sativa*)	Italy	Neutral sulphite	....	Semi	Sodium sulphite and caustic soda; single-stage bleach with calcium hypochlorite
328	Rice straw (*Oryza sativa*)	Java	De Vains	....	Full	....
329	Rye straw (*Secale cereale*)	Holland	Lime semichemical	....	None	....
149	Rye straw (*Secale cereale*)	Holland	Alkaline sulphite	Soft	None	Sodium sulphite and caustic soda
150	Sabai grass (*Eulalipos binata*)	India	Soda	Medium	Full	....
330	Sabai grass (*Ischaemum angustifolium*)	India	Sulphite	Soft	None	Magnesia base
331	Sal (*Shorea robusta*)	India	Soda	Soft	Full	....
151	*Sansevieria metallica* fiber	Florida	Soda	Soft	None	....
332	Sapota, American (*Achras zapota*)	Florida	Kraft	Soft	None	....
333	Sassafras (*Sassafras verifolium*)	North Carolina	Kraft	Soft	None	....
334	Savannah grass (*Saccharum spontaneum*)	New Guinea	Soda	Medium	None	....
335	Seagrape, common (*Coccolobis uvifera*)	Florida	Kraft	Soft	None	....
336	Silverbell, Carolina (*Halesia carolina*)	North Carolina	Kraft	Soft	None	....
152	Sisal (*Agave sisalina*)	Africa	Soda	Soft	None	....
153	Sorghum (*Sorghum vulgare*)	Italy	Neutral sulphite	....	None	Sodium sulphite and caustic soda
154	Spruce, black (*Picea mariana*)	Minnesota	Sulphite	Soft	None	....
155	Spruce, black (*Picea mariana*)	Minnesota	Sulphite	Soft	Full	....
156	Spruce, black (*Picea mariana*)	Minnesota	Sulphite	Soft	None	Sodium base
157	Spruce, black (*Picea mariana*)	Minnesota	Sulphite	Soft	Full	Sodium base
158	Spruce, black (*Picea mariana*)	Ontario	Sulphite	Soft	None	Mitscherlich process
159	Spruce, black (*Picea mariana*)	Ontario	Sulphite	Soft	Full	Mitscherlich process
160	Spruce (black and/or white)	Wisconsin	Kraft	Medium	None	....
161	Spruce (black and/or white)	Minnesota	Groundwood	....	Full	Peroxide bleach
162	Spruce (black and/or white)	Quebec	Groundwood	....	None	....
163	Spruce, eastern (*Picea* sp.)	New York	Groundwood	....	None	Presteamed; includes 25% balsam fir
164	Spruce, Engelmann (*Picea engelmanni*)	Colorado	Sulphite	Medium	None	....
165	Spruce, Engelmann (*Picea engelmanni*)	New Mexico	Kraft	Soft	None	....
166	Spruce, Norway (*Picea excelsa*)	Sweden	Sulphite	Hard	None	....
167	Spruce, Norway (*Picea excelsa*)	Sweden	Sulphite	Soft	None	....
168	Spruce, Norway (*Picea excelsa*)	Sweden	Sulphite	Medium	Full	....
169	Spruce, red (*Picea rubens*)	Maine	Sulphite	Medium	None	Mixed ammonia and calcium base
170	Spruce, Sitka (*Picea sitchensis*)	Alaska	Kraft	Soft	Full	....
337	Spruce, Sitka (*Picea sitchensis*)	British Columbia	Sulphite	Medium	None	Laboratory screened
338	Sugar cane bagasse (*Saccharum officinarum*)	....	Soda	....	None	Cooked in Holland; source unknown
171	Sugar cane bagasse (*Saccharum officinarum*)	Louisiana	Milled for juice extraction	Raw	None	Variable content of leaves and stalk
172	Sugar cane bagasse (*Saccharum officinarum*)	Louisiana	Steamed	Hard to medium	None	Disintegrated in water and steam digested for 1 hour
173	Sugar cane bagasse (*Saccharum officinarum*)	Louisiana	Kraft	Hard	None	66% yield
174	Sugar cane bagasse (*Saccharum officinarum*)	Louisiana	Kraft	Soft	None	60% yield
175	Sugar cane bagasse (*Saccharum officinarum*)	Philippine Islands	Pomilio-Celdecor	....	Full	....
176	Sunn (*Crotalaria juncea*)	India	Alkaline sulphite	Soft	None	....
177	Sweetgum (*Liquidambar styraciflua*)	Arkansas	Kraft	Hard	None	....
178	Sweetgum (*Liquidambar styraciflua*)	Arkansas	Kraft	Soft	None	....
179	Sweetgum (*Liquidambar styraciflua*)	Louisiana	Kraft	Soft	None	....
339	Sweetgum (*Liquidambar styraciflua*)	Georgia	Kraft semichemical	Low yield	None	Unbarked
340	Sweetgum (*Liquidambar styraciflua*)	Georgia	Kraft semichemical	Intermediate yield	None	Unbarked
341	Sweetgum (*Liquidambar styraciflua*)	Georgia	Kraft semichemical	High yield	None	Unbarked
342	Sweetgum (*Liquidambar styraciflua*)	Georgia	Kraft (Asplund)	Low yield	None	Unbarked

No.	Species	Location grown	Process	Degree of cooking	Bleaching	Remarks
343	Sweetgum (*Liquidambar styraciflua*)	Georgia	Neutral sulphite (Asplund)	....	None	Unbarked
344	Sweetgum (*Liquidambar styraciflua*)	Georgia	Neutral sulphite semichemical	Low yield	None	Unbarked
180	Tamarack (*Larix laricina*)	Minnesota	Kraft	Soft	None	....
181	Tamarack (*Larix laricina*)	Minnesota	Sulphite	Medium	None	....
345	Trema, Florida (*Trema mollis*)	Florida	Kraft	Soft	None	....
346	Tupelo, black (*Nyssa sylvatica*)	Georgia	Kraft	....	None	....
347	Tupelo, black (*Nyssa sylvatica*)	Georgia	Kraft	....	Full	....
182	Tupelo, black (*Nyssa sylvatica*)	Louisiana	Neutral sulphite	Semichemical	None	....
348	Tupelo, water (*Nyssa aquatica*)	Georgia	Kraft	Soft	None	....
349	Wattle, green (*Acacia irrorata*)	Australia	Kraft	Medium	None	....
350	Wattle, hickory tanning (*Acacia falciformis*)	Australia	Kraft	Medium	None	....
351	Wattle, silver (*Acacia dealbata*)	Australia	Kraft	Medium	None	Sapwood
352	Wattle, silver (*Acacia dealbata*)	Australia	Kraft	Medium	None	Heartwood
353	Wattle, silver (*Acacia dealbata*)	Australia	Kraft	Medium	None	....
354	Wax-myrtle, Southern (*Myrica cerifera*)	Florida	Kraft	Medium	None	....
183	Wheat straw (*Triticum vulgare*)	Indiana	Neutral sulphite	Hard	None	....
184	Wheat straw (*Triticum vulgare*)	Illinois	Neutral sulphite	Soft	None	....
185	Wheat straw (*Triticum vulgare*)	Illinois	Neutral sulphite	Soft	Full	....
356	Wheat straw (*Triticum vulgare*)	Holland	Neutral sulphite	Soft	None	....
186	Wheat straw (*Triticum vulgare*)	Holland	Alkaline sulphite	Medium soft	None	Sodium sulphite and caustic soda
187	Wheat straw (*Triticum vulgare*)	Illinois	Kraft	Soft	None	Hydrapulper
188	Wheat straw (*Triticum vulgare*)	Illinois	Kraft	Soft	Full	Hydrapulper
189	Wheat straw (*Triticum vulgare*)	Illinois	Soda	Soft	None	Hydrapulper
190	Wheat straw (*Triticum vulgare*)	Illinois	Soda	Soft	Full	Hydrapulper
191	Wheat straw (*Triticum vulgare*)	Illinois	Lime-soda	Soft	None	Washed and beaten
192	Wheat straw (*Triticum vulgare*)	Indiana	Lime-soda	Hard	None	....
355	Wheat straw (*Triticum vulgare*)	Holland	Lime semichemical	....	None	....
357	Wheat straw and oat straw	Holland	Neutral sulphite	Soft	None	50-50 mixture
193	Wheat straw and oat straw	Holland	Alkaline sulphite	Medium soft	None	50-50 mixture; sodium sulphite and caustic soda
389	Willow, black (*Salix nigra*)	Wisconsin	Sulphite	Medium	None	Ammonia base
390	Willow, black (*Salix nigra*)	Wisconsin	Neutral sulphite semichemical	Intermediate yield	None	....
358	Yaupon (*Ilex vomitoria*)	Florida	Kraft	Soft	None	....
194	Yawa fiber (*Vigna sinensis* var. *extilis*)	Nigeria	Soda	Soft	None	....
359	Yellow-poplar (*Liriodendron tulipifera*)	Virginia	Neutral sulphite semichemical	73% yield	None	....

RECENT BOOKS

Directory of Commercial and College Testing Laboratories. Compiled by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. 1955. Paper cover, 8 × 10, 39 pages. $1.00.

This publication replaces National Bureau of Standards Miscellaneous Publications M 187 of the same title which has been withdrawn from circulation. In the future, it will be issued by the ASTM.

The directory gives information regarding the location of 278 testing laboratories, together with the types of commodities and the nature of the investigations the laboratories are prepared to undertake. The major classification is by states. A code system describes the functions of the laboratories.

The Story of Papermaking. By Edwin Sutermeister, S. D. Warren Co. Distributed by R. R. Bowker Co., New York, 1954. Cloth, 6½ × 9½, 209 pages. $5.00.

From time to time short, elementary books have been written by individuals, many of these writers have indicated but little first-hand knowledge of the industry. The present book by Dr. Sutermeister will be welcomed by many people who may wish to recommend a book to individuals who are not acquainted with the operating details of pulp and paper manufacture but who wish to have a simple description. It will be especially valuable to high school students, newcomers to the industry, and to paper salesmen.

The book follows the usual pattern of raw materials, groundwood, soda, sulphite, sulphate and other pulping processes, bleaching, stock preparation, papermaking, coating, calendering, and finishing. An appendix of paper definitions is included.

Industrial Recreation. By Jackson M. Anderson, Director of Research, National Industrial Recreation Association. McGraw-Hill Book Co., New York, 1955. Cloth, 6 × 9, 304 pages. $5.00.

The growing recognition of the importance of recreation in the life of the industrial worker is evidenced by the increasing number of business and industrial organizations which have inaugurated employee recreation programs since the end of World War II. To meet this demand a number of colleges have established courses in industrial recreation. The author was a former professor of the subject at Lehigh University.

The subject is presented in three parts. Part I deals with the principles of industrial recreation. Part II takes up the industrial recreation program such as social, cultural, physical, outing, lunch hour, and community

activities. Part III covers administration of industrial recreation covering leadership, organization of the employees' recreation association, financing, and evaluation.

The appendix includes a model constitution and bylaws for the employees' recreation association, industrial recreation interest survey, and a list of national organizations providing recreation services.

Geography of the Northlands. Edited by George H. T. Kimble and Dorothy Good. John Wiley & Son, New York, 1955. Cloth, 6 × 9, 534 pages. $10.50.

American Geographical Society, Special Publication No. B 2 is written by fourteen experts who survey the physical conditions, economic resources, and cultures of the arctic and sub-arctic regions. The book is the first comprehensive text to appear in 20 years.

The subject is covered in two parts. Part I deals with systematic studies of physiography, water masses, weather, biogeography, marine life, aboriginal and immigrant population, transportation, resources, political and strategic aspects. The second part is made up of regional studies of Alaska, Northwestern and Eastern Canada, the Canadian Archipelago, Greenland, Iceland, Northern Scandinavia, and the U.S.S.R.

College Placement Directory. 2nd Ed. By O. T. Zimmerman and Irvin Lavine, University of New Hampshire, Dover, N. H., 1955. Cloth, $6^1/_2 \times 9^1/_2$, 577 pages. $10.75 ($11.50 outside U.S.A.).

Although most companies start early to investigate the availability of students for industrial employment, the College Placement Directory will provide much information of permanent value. The ready acceptance of the first edition proved the need for such a book.

Information is given about more than 1500 companies that have more than 50,000 college graduates each year. Details are given concerning all colleges and technical institutes. In each case the name of the college placement officer is given.

Manual of Excellent Managements. 1955. American Institute of Managements, 125 E. 38th St., New York 16, N. Y. Cloth, $8^1/_2 \times 11$, 160 pages. $20.

The second annual survey gives a continuing review of corporate operations in 1954 having outstanding company performances in each, the manual provides a full discussion of the categories; economic function of the corporation, corporate structure, health of earnings, service to stockholders, research and development, directorate analysis, fiscal policies, production efficiencies, sales vigor, and executive evaluation. The quality of executives is weighted most heavily.

A special feature of the 1955 edition is an actual audit of the Marathon Corp.

Business Management Handbook. Edited by J. K. Lasser. McGraw-Hill Book Co., New York. Rev. 1954. Cloth, 6 × 9, 809 pages. $8.50.

This well-known handbook has been revised and brought up to date in its third printing. As in the case with similar books of this kind the various chapters were written by specialists.

The title of each chapter begins with "How to" and chapters include such subjects as finance, organization, risks, start a business, market, organize good relations with customers, employees, stockholders, accounting, costs, avoid frauds, use budgets, and how to buy business insurance.

The aforegoing is an oversimplification of an excellent text that has been in considerable demand.

Organic Solvents. 2nd Ed. By Arnold Weissberger, Eric S. Proskauer, John A. Riddick, and Emory E. Toops, Jr. Interscience Publishers, Inc., New York, 1955. Cloth, 6 × 9, 552 pages. $8.50.

The present book is Volume VII in Interscience's "Technique of Organic Chemistry" series. The first edition was published in 1935 and has been completely revised by Riddick and Toops of Commercial Solvents Co. It is essentially a handbook covering the physical properties and constants of the solvents used in commerce.

Note: Books reviewed in these columns may be obtained through the Book Department of the Technical Association of the Pulp & Paper Industry, 155 E. 44th St., New York 17, N. Y.

LETTERS TO THE EDITOR

Rubber-Covered Press Rolls

To the Editor, *Tappi:*

At the Port Angeles mill we have been using rubber-covered top and bottom press rolls in both the first and second presses of our newsprint machines consistently for the past two years.

We have realized an increase of felt life from a 14-day average to 60-day average on the first press, and from an 18-day average to a 100-day average on the second press. Prior to using rubber-covered top press rolls we were using stonite rolls. The bottom press rolls have always been rubber covered.

In the second press top position we have been able to run any good quality rubber-covered roll of 45–55 P.&J. $^1/_8$-in. ball plasticity without crumbing or picking out. However, in the first press position the only successful covering has been the "self doctoring top press roll covering" developed by Griffith Rubber Mills of Portland, Ore. This is a secret patented covering which we have applied to our old cast-iron roll cores. The plasticity of this cover is 50–55 P.&J. $^1/_8$-in. ball. The bottom suction rolls are rubber covered and have a 40 to 45 P.&J. $^1/_8$-in. ball plasticity. On our rubber-covered top press rolls a solid micarta doctor blade fitted very flat to the roll to avoid digging in is used.

Our chief problem with these first press top rolls has been proper grinding to avoid crumbing and picking out. Lately we have had most success dry grinding with an open wheel of 24 or 30 grit. Even with these wheels slow feed and traverse are necessary to avoid loading up the wheels.

As far as water removed on the presses is concerned, the use of rubber-covered rolls in second presses resulted in an increase in dryness of about 2%, or an increase from an average of 33 to 35% oven dry. The use of these rolls in the first presses has not measurably increased with dryness. The moisture variation across the sheet is much less with rubber-covered top press rolls.

Other factors which we feel play an important part in water removal in the presses are felt condition and cleanliness and press loading. On the average our first presses are loaded to a total pressure of 180 pounds per inch of roll face and our second presses to 200 pounds per inch of roll face.

We trust this information will allow you to answer the inquiry you have from the Clyde Paper Co. For further information on the "self doctoring top press roll covering," please contact Robert Bear of Griffith Rubber Mills, Portland, Ore.

T. C. Smyth
Crown Zellerbach Corp.
Port Angeles, Wash.

EMPLOYMENT SERVICE

Positions Wanted

E301-55. Chemical Engineer; 34, married; 9 years' pulp and paper experience in supervisory, development, and control work. Acid and alkaline pulping, book and bond paper. Desire position with opportunity and challenge in supervisory or development work with a progressive company.

E306-55. Chemical Engineer with a B.S.Ch.E., M.S.Ch.E (pulp and paper) and expecting to complete Ph.D. in chemical engineering in September, 1955, seeking employment with the pulp and paper industry. Age 26.

E307-55. Chemical Engineer, 29 years old, 8 years' experience in newsprint and specialty paper mills, covering research and control work in mechanical and chemical pulping, waste measurements, and other phases of technical control. Desires position in Midwest in technical department or as technical assistant to production superintendent.

Positions Open

P437-55. Major Boxboard Producer and Converter needs technically trained man. Must have at least two years' experience in board mill operation or in coating of board or paper. Experience in machine or off machine coating acceptable.

P444-55. Coating Chemist. Excellent opportunity for graduate chemist or chemical engineer with experience in clay coating of enamel and machine coated printing papers. Must be capable of organizing plant scale development work. Location—Midwest.

P446-55. Man with technical education and production experience for Assistant Technical Director with opportunity to transfer to Production Manager or Mill Manager. Fine papers and specialties. At least ten years' experience necessary. Write giving experience and salary expected.

P451-55. Chemist. Some knowledge of boxboard and paper and the application of ink in a printing plant located within 59 miles of New York City. Apply in writing stating experience, education, and salary desired. National Biscuit Company, Advertising Department, 449 W. 14th Street, New York, N. Y.

P452-55. Chemist or Chemical Engineer with pulp and paper mill experience. Mill located in the South with excellent opportunities for advancement. Please send résumé of educational and industrial experience together with salary expected. All replies held in strictest confidence.

ITALY

Italian firm seeks sales representation for U. S. or Canadian pulp mill. Well known throughout the Italian pulp and paper industry as representative of some of the largest pulp and paper machinery manufacturers of Europe and U.S.A. Reply to TAPPI, P453-55.

Position open for man with kraft mill experience as supervisor of erection and start-up of Kamyr Continuous Cooking Plant. Must be willing to travel. Reply to TAPPI, P454-55.

P455-55. Project Engineer with creative aptitudes for paper machinery development in New England area. Applicant must have several years of development engineering experience and be able to readily apply fundamental laws of fluid dynamics and applied mechanics to creative work. He must be able to think in terms of and perform simple experiments for verifying ideas. He will be expected to make design layouts and specifications for subsequent detailing and manufacture. High-speed paper machine design or operating experience is desired, but not essential. Applicants to enclose photograph with complete résumé of educational and industrial backgrounds, including present salary and salary expected. All applications will be held in strict confidence.

P457-55. Project Engineer—Young chemical or mechanical engineer to work out of Technical Department on mill problems; process design, material balances, equipment evaluating, chemical additive systems auxiliary to paper machines. Much variety. Several years' experience preferred. Salary based on experience and capabilities.

P458-55. Chemist or chemical engineer for research and development work in sulphite and semichemical pulping, pulp processing, and by-product utilization. Laboratory or pilot plant pulping and testing experience necessary. Northern Wisconsin location. Please give personal history, résumé of experience and training, and indication of salary requirements in reply.

PAPER MACHINE OPERATOR

Here is an exceptional chance to participate in an exciting new development of different paper techniques. We are looking for an experienced paper-maker to operate a pilot-size machine and develop brand-new kinds of paper sheets.

A college degree is not essential, but ingenuity and high mechanical aptitude are pre-requisite. You must have had practical experience in making paper, desirably on a small-scale machine, and must have a flair for working on development problems without close supervision.

We feel this is a challenging opportunity for individual growth in a large diversified company that is well established and stable. Location—New England with enjoyable living conditions.

If you qualify for this position, please write to us promptly. Tell us about your background and desires for the future. List your salary requirements. We will carefully maintain all confidences. Our employees know of this ad. Send reply to Box P 456-55.

TECHNICAL SALES ENGINEER

Graduate of university specializing in paper to be Assistant to Director of Industrial Sales. Must have had experience on technical or industrial papers made on either fourdrinier or cylinder machines. Previous sales experience not important. State fully practical experience. Salary $7,000 to $10,000 plus bonus. Reply P460-55.

P461-55. Young Chemist or Chemical Engineer with or without previous paper mill experience to assist Chief Chemist in the Main Laboratory of a large integrated fine paper mill located in Northern Wisconsin. Please give a complete résumé in first letter, including salary requirements.

Note: Responses to all advertisements should, unless otherwise indicated, be sent to TAPPI, 155 E. 44th St., New York, N. Y.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Delaware Valley

The Dec. 10, 1954, meeting of the Delaware Valley Section of TAPPI was held at the Engineers Club in Philadelphia. About 100 persons were present.

Chairman Emil Padavic opened the meeting and announced that Ed Molin, first vice-chairman and program chairman, had resigned his office due to taking a new job with Deerfield Glassine Co. in Quebec City. The Section is very sorry to loose Ed but wishes him every success in his new venture.

During the business meeting, Chairman Padavic presented an engraved desk pen set to Past-Chairman Frank J. Lovegren of P. H. Glatfelter Co., Spring Grove, Pa. Mr. Lovegren expressed his continued appreciation for the cooperation given him by the Section through the years and voiced his desire that such cooperation would continue with both the present and future administrations of the group.

The chairman then briefly outlined the subject for discussion by the panel which was "Latest Developments in Beater Additives." The first speaker for the panel was H. O. Ware of the Hercules Powder Co.

Mr. Ware stated that beater additives cover a wide variety of chemicals, rosin, pigments, dyes, sizing, latex, wet-strength resins, starches, gums, synthetic resins, etc. In order to narrow the field one might discuss phenomena rather than the additives, and further narrow the phenomena to improvement of dry strength by use of additives. Mr. Ware's remarks are paraphrased below.

"Tear, a strength characteristic, for a given pulp varies with beating time and this relationship can be plotted giving the characteristic curve showing generally a decrease in tear with an increasing beating time.

"Bursting strength, a different strength characteristic, similarly plotted, shows an increase with beating time. Consequently the question arises as to which beating time for a given pulp produces the sheet with the most strength.

"Further consideration of this matter shows that a definition of tear and bursting strengths may be obtained if tear versus burst is plotted for a series of different beating times on a given pulp. Such a graph shows a sharp decrease in tear as the burst increases.

"This same method can be used for other characteristics particularly strength factors which tend to increase with increased power input versus strength factors which tend to decrease with increased power input. In this way it is possible to obtain a 'definition' of the relationship of one strength characteristic in terms of another characteristic.

"An interesting relationship is pictured if tear versus bursting strength is plotted for different basis weight sheets prepared from the same stock. Such curves show the strength improvement to be expected by increasing the amount of fiber.

"If two different stocks (i.e., sulphite and deinked) at a fixed basis weight are both tested at various beating times, the plot of these points is similar to that for different basis weight sheets from the same stock. If a line is projected from the origin through both curves, the distance a from the origin to the lower curve and b, the distance between the curves, provide reference points. Here the relative strength of the sulphite is $(a + b)/a$ greater than the strength of the deinked. Using these methods it is possible to define the effect which a beater additive will exert on strength in terms of replaced 'fibers.' Another tendency which is found to be present when these methods are used is the effect of the beater additive on displacing the curves downward and to the right. This displacement may be described as 'power substitution effect.' The 'replaced fibers effect' tends to move the curves upward and to the right and this movement is not so easily affected as the 'power substitution effect.' Power substitution effects as high as 95% have been known, and similar amounts of power replacement have a much greater effect on unbeaten fibers as compared to beaten fibers.

"Beating increases sheet density and the additive giving similar freeness effects will not affect the sheet density to the same degree as beating. By manipulation of such functional differences it is possible to obtain 'disproportionality of physical qualities.' Thus, it may be possible to get desirable properties by use of additives without adversely affecting other properties as much as usual methods would.

"In summation, one can say that, for a case in point, it is necessary to determine what is actually obtained by use of the additive: (1) fiber substitution (use of less strong fibers or increased strength), (2) power substitution (use less power input to get similar effects, and (3) paper properties may be varied disproportionately."

The next speaker was J. S. Hickman of the Organic Chemicals Dept., E. I. du Pont de Nemours & Co. Mr. Hickman spoke on the "Addition of Elastomers to Paper." His remarks in general were as follows:

"Elastomers may be added to paper by saturation methods to either wet or dry webs or in pulp slurries. Saturation is the older art but most paper mills do not saturate because of the high cost of equipment necessary for this method. For pulp slurries, conventional equipment is often easily modified for additions of three types as follows: (1) neoprene or chloroprene, (2) buna N or acrylonitrile types, and (3) buna S or GRS types. In all types the polymerization is accomplished in such a way that the material is left in a dispersed form, although at times a dispersing agent is required. Prior to dis-

E. R. Padavic, present chairman of the Delaware Valley Section giving gift of appreciation to F. J. Lovegren

persion, the lattices must be well stabilized. Some factors which must be avoided are incompatible pH values, high salt concentrations, shock, pressure, etc.

"Some types of elastomers are more easily handled than others. For instance, compounding of ingredients is always necessary with neoprene types and these usually require dispersants. In adding to the beater the following steps are generally required: (1) pH adjustment of the pulp slurry with some alkaline material, (2) compounding if required, (3) addition of the latex, (4) dispersal of the latex without premature coagulation, and (5) addition of coagulant which is usually alum but may be other acidic material. Best results on all types appear to be obtained if stock refining is eliminated after latex addition. Refining equipment usually tends to dislodge the additive and the elastomers, while dislodged, give rise to serious problems.

"Poor or adverse addition techniques force the adoption of: (1) adequate felt washing; (2) Stonite, Rub-Rock, brass, or other hard surface rolls; (3) a system free from solvents; and (4) the elimination of dragging surfaces such as spreader bars.

"The use of neoprene in various amounts gives paper products with varying properties. Low percentage addition (0.5 to 2.0%) gives good wet strength. Good folding endurance, no loss of tear, chemical resistance, and high degree of sizing are obtained at medium percentages (2 to 10%). These amounts result in reinforcing the fiber-to-fiber bonds and show best results on relatively 'free stock.' Good board-forming properties are obtained in this range. The high percentage addition of neoprene (10% plus) produces excellent swell resistance in oil, water, and fuels and very high elongation and tensile.

"At low percentage addition, a controlled dispersing action is required in order to obtain proper efficiency from the additive. The discrete deposition of the neoprene should follow the flocculating of the papermaking fibers. As the percentage of neoprene is increased, the elongation property improves and this will vary depending on the particle size applied. There also seems to be an improvement in effects that is dependent upon the degree of stock refining. The following table indicates some effects of increased percentage of neoprene."

Neoprene, %	0.0	8.9	20.5	30.8
Tensile	4,600	5,200	6,000	5,500
Tensile product	11,500	23,000	33,100	35,400
Wet tensile, %	5.1	53.7	63.6	62.5
Edge tear/in. width	9.3	17.0	17.6	20.3
Internal bonding	88	176	213	263
Strength, lb.				
Stiffness, p.s.i. $\times 10^3$	210	80	95	40

The next speaker was Paul McLaughlin of the Rohm & Haas Co.

"The acrylic resins used today are not water soluble but are used in water emulsions. The strength of paper made with acrylic resins is affected by the different polymer brittle points.

"The field studies on this type of beater additive are limited. Two acrylics designated as Rhoplex MR and experimental emulsion E-80 are currently being studied.

"When acrylics are added to asbestos fiber, no alum is required for deposition since the best effects are obtained with a 'soft' polymer (i.e., low brittle point). For glass fibers soft polymers are also recommended.

"One of the novel aspects about acrylics as beater additives is the fact that they cause little or no change in air porosity or water penetration rates as do the elastomers. Since the acrylic polymer is polar, it is thought that the absorption of water is aided by the presence of the resin."

McLaughlin stressed three points about acrylic resins: (1) the amorphous glassy nature of the acrylics is the basic reason for the sharp differences demonstrated from the elastomer type polymer additives, (2) dry strength improvement is attainable without increase of wet strength, and (3) the acrylic polymers are stable to light and to other materials which may be incorporated in the sheet.

1954–1955 officers of the Delaware Valley Section: C. R. Calkins, treasurer, Riegel Paper Corp.; E. R. Padavic, chairman, Container Corp. of America; P. E. Nethercut, program chairman, Scott Paper Co.; and C. F. Ackerman, secretary, Union Mills Paper Mfg. Co.

The fourth speaker was M. L. Cushing of Stein, Hall & Co.

"Synthetic additives may some day rule the field of beater additives, but today large quantities of starches and natural gums are being used.

"It is well known that strength improvement is obtained with the use of locust bean gum or guar gum in the beater. The novel idea is that there is currently available a new guar gum which is cold water swelling, and that may be added dry without the lumpiness, fish eyes, etc. that were formerly experienced upon dry addition to the beaters.

"The structure of this new additive is believed to be mannose 1,4, beta linked with galactose molecule linked periodically. The single galactose molecule sticking up would have the structure, upon the larger molecule, similar to a rake or a comb. Such a structure is similar to the structure of cellulose. This theory is difficult to prove but is an interesting hypothesis. Such a rigid linear molecule could readily associate, or hydrogen bond, with cellulose.

"The new guar overcomes some of the objection to previously used material. The ready hydration tendency of the natural gum created lumps. Borax was used to counteract this lumping and the resulting change in pH created other complications. The new guar has been run in Canadian mills with cold waters and in southern mills where the stock temperatures are about 145 to 150°F. Added dry, the new guar will disperse. Retention, as quoted by Lynch in the August, 1954, issue of *Tappi* shows 90% retention on a 5 to 10-lb. per ton dosage. Such a retention is difficult to achieve when with starches.

"The action is principally that of deflocculation but an adhesive function is also believed to be operative. The deflocculation aids in formation. Increases in bonded area as a result of the new guar addition produce papers with increased burst, tensile, and fold. Improved surface characteristics were observed: less lint and fuzz, better printability, denser sheet, better brightness, and opacity. The additive created a faster draining stock upon the wire and an increased wet strength for bridging the couch gap. On filled papers ash content may be increased by increasing the filler 5 to 10 lb. per ton without sacrificing physical strength. A decrease in two-sidedness also results which applies not only to fines but also to composition two-sidedness. Without guar the felt side showed 12% ash and the wire side 5%. With the new guar the felt side ashed at 11.2% and the wire side 8%."

Following the formal presentations the panel offered to answer questions from the floor. Joe Paciello, du Pont Dyestuffs Division, served as moderator for the question and answer period.

J. P. Weidner, Container Corporation of America: What about the wet-strength characteristics of the acrylic polymers?

Mr. McLaughlin: Practically no wet strength is exhibited.

C. F. Ackerman, Union Mills Paper Manufacturing Co.: How does guar act on well-beaten stock as against stock having had a low beating time?

Mr. Cushing: The guar frees the stock during the normal beating cycle by protecting the fibers. Such treated stock will drain better at the same freeness value than another stock without such an additive.

P. E. Nethercut, Scott Paper Co.: Was this unexpected?

Mr. Cushing: Yes, the kraft mills were surprised.

Question: Do you have any experiences with thermosetting beater additives such as phenolics?

Mr. McLaughlin: I have no first-hand knowledge.

John Manley, Lockport Felt Co.: How are dimensional stabilities affected by additives other than guar?

Mr. McLaughlin: Rohm and Haas has made no serious effort to effect dimensional stability. The tendency is toward water-soluble acrylics.

Mr. Hickman: With neoprene, an initial high sizing results but after wet out, or in very moist atmosphere, the improvement in dimensional stability is not great, only 10 to 20%.

Mr. Cushing: Guar affects dimensional stability only as it effects curl, particularly offset. Here it does minimize curling tendencies.

Mr. Ware: I believe dimensional stability is directly related to the freeness through the stress-strain relationships. Beater additives which retain high porosity (low densometer) should improve dimensional stability.

Don Kane, Hercules Powder Co.: Would Mr. Hickman care to define his terms and explain how they were determined for internal bond figures quoted?

Mr. Hickman: The internal bond strength might be defined as the plane to plane forces as against those in a longitudinal direction. A modification of Sutermeister's method is used in which both sides are adhered to buttons and the buttons pulled apart by means of adapted tensile tester jaws.

Henry Maeder, Dixie Cup Co.: What adhesive is used and how much penetration occurs into the paper?

Mr. Hickman: A solvent-base neoprene adhesive is used to coat the buttons which are heat aged for 15 to 20 min. then recoated and re-aged at 100°C. After this treatment the adhesive has lost the solvent and is still tacky, and there is little chance for strike through.

Mr. Ware: Isn't this essentially the same as the Dennison wax pick test? How does it compare with an instantaneous velocity test which is a printing speed test?

Mr. Hickman: The wax is unreliable because it is thermoplastic.

F. J. Lovegren, P. H. Glatfelter Co.: Nothing was said about applying the button hot.

Mr. Ware: I am concerned with flow properties, either hot, as with the wax, or cold as with the pressure-sensitive buttons. Is the method as reliable with a Buna N-base adhesive? What is the correlation with printing speed test with oil-base inks?

R. H. Walsh, du Pont: The correlation is good.

H. C. Brill, du Pont Pigments: Does neoprene lend any fire resistance to treated papers so that it will not support combustion?

Mr. Hickman: Neoprene will burn if the fire is held on it but not if the flame is removed. Any burning tendencies would be magnified by the cellulose in the paper. Asbestos fiber–neoprene compositions are satisfactory.

Mr. Brill: I was thinking about the wartime test which required 15-sec. contact with a Bunsen burner flame and then removed. To pass, no burning could continue on the material.

Mr. Hickman: Over 20% neoprene would be required and it would not impart any flame resistance to the cellulose.

J. Howard Wright, Bauer Brothers: Must the guar be used dry or must it be slurried for addition to the fan pump?

Mr. Cushing: It must have time to become completely swelled, about 15 to 20 min. Dry addition at the fan pump would give minute but discrete particles in the sheet on the machine. Cooking it should be satisfactory.

I. D. Tharp, Paper Manufacturers Co.: Is any electrical resistance imparted to the paper by these beater additives?

Mr. McLaughlin: It has not been measured by Rohm and Haas with the acrylics but none would be expected.

Mr. Hickman: Neoprene plus other materials as zinc oxide or aluminum sulphate will improve this characteristic.

Mr. Cushing: With the similarity to cellulose and a 1% addition of guar, we expect a minimum effect on electrical resistance.

B. M. Miller, du Pont Engineering: Will guar deflocculat any aspen pulp?

Mr. Cushing: Yes.

Mr. Wright: Has guar been used to control adhesion or dry crepe on a Yankee drier or to control softness?

Mr. Cushing: The material is relatively new and experience is limited.

Joseph Judge, Riegel Paper Co.: Do any of the additives affect ply adhesion on a cylinder machine?

Mr. McLaughlin: Rohm and Haas is studying specific adhesion but products are not ready for the market, yet.

Mr. Hickman: Neoprene will improve adhesion, not necessarily in all cases, however, and especially not if other properties are poor.

Mr. Judge: This is difficult to do without imparting wet-strength properties.

Mr. Ware: Regarding the utilization of Lycoid gum and its solubility time, do you visualize the most efficient application at molecular level or when only partial solubility has taken place?

Mr. Cushing: We are in the process of making up our minds on that one. As it runs longer, better results will be obtainable, but probably it is greater at the molecular level. There are too many factors to be certain.

Mr. Manley: What are the pH requirements?

Mr. Cushing: None with this guar. It is not now a borated composition. The borated gums are poorer under alkaline conditions. This new guar will disperse equally well at pH values over or under 7.

Mr. Weidner: What is the effect of alum on the guar?

Mr. Cushing: Morrison and Swanson recently published on this subject and found that the alum affected the deflocculating action so that it is not quite as good in the presence of alum. There are only hydroxyl groups which are reactive on the guar.

There being no further questions the meeting was turned back to Chairman Padavic who adjourned it after thanking the panel members for the fine program.

January Meeting

On Jan. 27, 1955, the Delaware Valley Section met at the Engineers Club on Spruce St. in Philadelphia at a joint meeting with the Philadelphia Printing Ink Production Club. The program was highlighted by a forum and panel discussion on graphic arts with William Walker as moderator. Mr. Walker is a member of the National Printing Ink Research Institute at Lehigh University.

Papers were presented by two printing house representatives, one inkmaker, and one papermaker.

These were:

Foy Gilchrist, general manager, Printing Div., Beck Engraving Co., Philadelphia.
Philip Tobias, technical director, Edward Stern & Co., offset printers, Philadelphia.
Charles H. Ross, Sinclair & Valentine Co., Philadelphia. (Mr. Ross is also chairman of the Printing Ink Production Club.)
Philip H. Hershey, acting technical director, P. H. Glatfelter Co., Spring Grove, Pa.

After presentation of these papers the speakers were joined by Joseph Krause of the Peerless Printing Ink Co. and Joseph J. Schwenkler of the Container Corp. of America. The meeting was then thrown open to discussion.

Mr. Gilchrist of Beck Engraving Co. spoke generally about problems in letter press and gravure printing. He stated that in the final analysis, the printer looks for the best sheet which will keep his presses running. The sheet must have good printability. This quality is not easily defined but a satisfactory paper will have the following characteristics: (1) flatness, (2) freedom from dirt and slitter dust, (3) correct moisture content, (4) affinity for the ink to be used on the job, (5) good drying properties after printing, (6) freedom from static electricity, (7) good optical properties, (8) correct size of sheets, and (9) correct packaging.

Charles Ross of Sinclair & Valentine stated that ink problems could best be solved by mutual discussion between inkmaker, papermaker, and printer before the job goes on the press. This advance preparation should minimize the press down time and will perhaps eliminate such delays in a great many cases. Generally, the problem of the inkmaker is confined to making an ink do a certain job on a certain paper with

Members of graphic arts forum and panel: P. H. Hershey, P. H. Glatfelter Co.; P. Tobias, Edward Stern & Co.; J. Krause, Peerless Printing Ink Co.; F. Gilchrist, Beck Engraving Co.; W. Walker, moderator, National Printing Ink Research Institute; C. H. Ross, Sinclair & Valentine Co., chairman, Philadelphia Printing Ink Production Club; and J. J. Schwenkler, Container Corp. of America

some certain printing press. If samples of ink and paper are available from past press runs, these can be used to good advantage in preparing for subsequent press runs.

The remarks of Mr. Tobias and Mr. Hershey are printed below.

What the Printer Would Like to Have from the Papermaker

Philip E. Tobias

I HAVE been asked to speak, as a printer, on "What the printer would like to have from the papermaker." In deference to the needs of the other branches of printing, I would like to confine my remarks to specifically "What the offset printer would like to obtain from the papermaker."

I would like to begin by outlining the printer's problem. He combines and attempts to control photographic techniques stripping and opaquing operations, offset platemaking, press and finishing operations—the result is a job which he delivers to a highly critical, excitable, and necessarily dollar conscious customer. In this complex conversion, there is no question that paper is the biggest single item of raw material, not only from the standpoint of cost, but in ultimate effect on the efficiency of operation, and, consequently, the primary printing cost. Our company can illustrate the first factor in that our paper costs are somewhat less than one third of our total billing. Not only is paper important from a financial investment standpoint but also from an operational one. It is indeed a sad commentary that printers, notwithstanding the importance of this raw material, have so few specifications and provisions for quality control. I believe that the control method in general use consists of ordering a lot of paper, putting it on press, trying to run for several hours—if impossible, telephoning supplier, replacing or battling job through, losing schedule, money, quality, temper; and sometimes, losing the customer. I don't believe that anyone in this room would consider this an adequate method of quality control. At present, the situation of paper control is extremely serious for the printer. About 40% of the jobs that are run are adversely affected to some degree by the condition of the paper. The degree of adversity extends from a condition of no productive output to a point of a few per cent reduction in standard production speed.

I don't want to give the impression that all of this is on the negative side. The distribution of any one of the properties of the paper is, in general, a mathematically normal one. Any property of the paper will vary sizably above and below the mean value. Unfortunately, no matter how good a given lot of paper may be, it cannot make up for the damages suffered from a lot of paper which may have reduced the production rates to, for example, 50%, because of register, feeding, dirt, or whatever. Even with excellent paper, production rates are then limited by the equipment, occasionally by ink, and to a degree by personnel. These points are mentioned not as a "gripe," but as a measure of the effect and the indication of the necessity for tightening up controls. This is not a plea for a better substitute for paper. Paper at its best is a wonderful material. It's attractive, holds size well when treated well, is available in a number of different colors and surfaces, and is relatively cheap.

This is not a plea for the ideal material which would have the beauty of a handmade sheet of paper with the dimensional stability of a sheet of glass, the brightness of magnesium oxide, the strength of steel, the printability of the unknown ideal, but not to exceed a cost of 5¢ a lb.! My plea is for something attainable, the lack of which is now costing the printer a good percentage of a meager profit, and the control of which should rightfully be in the hands of the papermaker.

This is meant to be a plea for closer control of those properties which we have found have so profound an effect upon the efficiency of the printing operation. Some of these properties will require development of techniques for measurement; for others, techniques are well established. It is necessary that these tests be developed and, by proper statistical evaluation, the maximum limits of allowable variation be established. The statistical data must be obtained by reference to the printing operation. The effects of each variable on the ultimate printing cost must be evaluated and controlled to minimize the total printing costs. I am not trying to say that this might not cost the printer more for the raw material. Remember, the important thing is that the total costs of the paper and the printing production should be kept to a minimum.

The printer is an incurable optimist. He generally estimates jobs with the assumption that there will be no trouble. By experience, the unrepentant optimist finds his optimism ill-advised, but through the necessity of meeting the competition of his brother optimists, he returns to err again. The result is a very small profit return on his invested dollar. There probably isn't a single printer who doesn't budget at a low profit. What are some of the factors that we normally don't count on which may have a profound effect on production costs?

Probably the most important factor in an expensive sheet of offset paper is that of moisture content—or, more accurately, the equilibrium relative humidity of the sheet. The departure of a sheet of paper from the relative humidity of the pressroom results in more troubles than I have time here to mention. The moisture discrepancy is usually found to be on the low side with the result that the sheet will generally have a wavy edge which immediately restricts the maximum speed at which the sheets will feed down to the register guides. This wave will also affect the fan-out of the sheet and will finally affect the maximum speed at which the sheet will be delivered and jogged in the delivery pile. The wave can result in wrinkle which, in some cases, can be prevented by cutting out packing and very carefully adjusting press conditions—all at a very expensive cost per hour. Or, if the printer isn't so fortunate, and is unable to cut out the packing to compensate for the wave, he lifts the job, calls his paper merchant, with a somewhat unpleasant delay in delivery, additional costs due to makeready, and a resultant loss to the paper merchant and mill. Then, of course, the discrepancy in humidity may have a large effect on the over-all size, making its second trip through the press hazardous from the standpoint of register.

In the past few years the humidity situation has improved to a degree. The extent to which improvement remains to

PHILIP TOBIAS, Technical Director, Edwin Stern & Co., Philadelphia, Pa.

be made is exemplified by a series of humidity readings that we obtained on a series of papers received over a period of several weeks. Now, these papers were ordered with the specification that the equilibrium relative humidity of the paper be 53%—plus or minus 3%. I would like to list these values for the results obtained by direct measurement on the skids: 45, 41, 41, 41, 42, 39, 51, 45, 38, 37½, 40, 45, 20, 25, 38, 41, 41, 44, 25%. Remember, our specification called for 53%—plus or minus 3%. Exactly 1 out of 19 was within specifications, and 7 out of 19 were below 40%, which is the lowest limit to give passable register.

These results are by no means restricted to the local suppliers of paper, but are apparently a widespread phenomenon.

George Hammer, of Forbes Litho in Massachusetts, reports in a statistical study that he described in the Proceedings of the Technical Association of the Graphic Arts, May, 1954, results very similar to the ones that I have just given you. The problem of humidity is not a recent one, but it has become more acutely apparent to the printer as a control problem, as increasingly more pressrooms have become air conditioned. Prior to this, the control of paper humidity was meaningless if the ambient humidity of a pressroom were capable of 30 to 50% swings within a few hours. I am sure that this problem is not new to you gentlemen; that there are production problems which prevent an easy solution.

The printer needs a solution to this problem sorely. I believe that the problem can be rectified at a very low cost. Even conditioning of paper, which for most printers is not always a practical solution, might cost the mill less than about a third of a cent per pound. However, it is my understanding that the results are much more satisfactory if the humidity of the paper is reduced down to the final results required, rather than if it were wet from a dry state to the required value.

I should now like to cover the second important factor affecting the efficiency of press operations. This characteristic actually runs together many different basic properties of paper. I would like to refer to them generically as "dirt." Dirt may be caused by lumps of size, pieces of bark, splices, picking, and separation of the paper surface, slitter dust, and many other types of foreign material. This characteristic tends to vary widely in severity from mill to mill, but I dare say every mill has, at one time or another, been guilty of supplying dirty stock. The normal washup of a blanket to remove dirt, which, when incorporated with the ink, gives a poor quality reproduction, is done about every 3000 impressions. Dirt and lint from paper pulp can reduce this figure to 200 sheets between washups. It is generally at this point that we lift this job. Can you surmise what this does to operating costs? And to quality? The average impressions per hour can, with a moderately dirty stock, drop by 20%. This, as you can well believe, can completely wipe out the normal profit markup. Some of the sources of dirt are subject to ready control through inspection—namely, slitter dirt, foreign material, and loose sizing. The problem of picking—which I have thrown into my general classification of dirt—I know, is not so easily eliminated or controlled. There are, however, many likely designs of pick testers which I trust will eventually give some measure of the surface picking of paper. I am certain that the development of an accurate method of pick testing plus the establishment of necessary operating limits, will contribute substantially to increasing the efficiency of the printer's operations.

I would like to sum up the main things that the offset printer wants from the papermaker. He wants a sheet that is bright, ink receptive, stable, clean, and uniform. The quality should be such as to give the optimum efficiency in terms of printed sheets per dollar, *repeatedly* and *with certainty*. This requires control on the part of the papermaker, better controls than are apparent at present to the printer receiving the paper. Not only must there be set up significant measurements, but there must also be established limits. These limits cannot be determined with the papermaker operating in a vacuum, but must be set up by correlation with the observable results in terms of production, in sheets per hour off a printing press. What is in it for the papermaker? More profit from fewer returns, and more paper sold if the printer succeeds in trimming his costs, satisfying his customers, and thereby attracting more business away from other media.

Paper—As Concerns Printability and Ink

P. H. Hershey

For at least two or three decades the paper industry has been growing increasingly aware of the realization that to do an intelligent job of producing quality printing papers (or board) it must acquire a more profound working knowledge of the technicalities of the printing trade. This is especially logical when we consider that of the 26.5 million tons produced in the United States for 1953, approximately half, representing a valuation of 2.5 to 3 billion dollars, was destined to be printed (*1*). Based on more recent estimates these figures could be doubled by 1975.

Much has been written and spoken by experts along the lines of printability, ink, and paper, and while there are still vast areas in which we need technical enlightenment and understanding, much has been learned to clarify problems of mutual interest to printer, ink manufacturer, and papermaker. These three industries realize that in a definite sense they are interdependent, and thus they should work together in the harmony of enlightened knowledge of each other's problems.

Today, technical manpower is being trained toward specializing in an understanding of the technicalities of papermaking, ink, and printing combined. In at least several cases of our knowledge we see the ultimate, namely, paper mills employing full time printers who operate commercial scale presses to (1) evaluate their products printability-wise as a means of quality control, and (2) to function in research.

My remarks are by no means to be considered those of an expert in either printing, ink, or for that matter paper related to printability. I would like to refer to some of the more notable contributions of those experts whom we consider classical pioneers in these fields, along with some of our own related experiences in the investigation of paper problems. Subjects to be included are: (1) printing quality evaluated in terms of halftone reproduction, (2) a comparison of the three systems of printing in producing halftones, (3) the influence of paper properties on dot reproduction, (4) ink transfer, (5) print-through, and (6) picking.

In a broad sense we might sum up that printing quality is dependent in the last analysis on the surface qualities of the paper, e.g., smoothness, ink receptivity, resilience, etc., in physical relation to the inked imprinting mechanism whether type face, rubber blanket, or intaglio plate. In order then to understand completely the influence of paper surface as related to the various printing systems, we will temporarily have to borrow from the technology of the printer.

From the somewhat classical approach we would think of printing quality in terms of discontinuous reproduction. In type and line drawings the quality is evaluated by the contrast with the background and the sharpness and uniformity of the printed reproduction. In evaluating the reproduction of halftones (which is of course the critical test of paper printability) the smoothness of gradation of the tone value between high lights and shadows is important. The over-all effect appeals to the observer, but the general impression is conveyed by the blending of individual effects.

Without resorting to the details of photoengraving, the character of the individual dots, i.e., the manner in which they are reproduced, determines the quality of the printed halftone in the various printing processes. According to Bernstein (*2*) who made an extensive study of dot formation

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there are two main factors, namely sharpness of contours, and the uniformity of ink coverage, which determines the quality of the halftone. Sharpness of the dot contour is defined as the acuity of focus of the outline of the dot, while the uniformity of ink coverage is the evenness of ink distribution over the area occupied by the dot. Ideal sharpness of contours and evenness of ink coverage will of course lead to sharpness of detail and fullness of contrast in the printed reproduction.

Voet (*3*) illustrates the characteristics of halftone dot reproduction for the various printing processes in a series of photomicrographs. His somewhat detailed findings I have tried to summarize in Table I.

In letterpress printing the sharpness of dot contour is generally good while the uniformity of ink coverage within the dot area is poor. This would mean as far as the printed reproduction is concerned that there would be good sharpness, contrast, and sparkle. However, this is accompanied by poorer hue gradation (hue is defined as the particular shade of color).

Offset printing is to some extent the opposite with regard to dot characteristics with poor sharpness of dot contour, but good uniformity within the dot area. This is understandable since in transfer from plate to blanket, and then from blanket to paper, sharpness of contour is lost; but at the same time with the uniformity of printing pressure resulting from flatness of the plate and resilience of the blanket, it is natural to attain good uniformity of dot coverage. Accordingly, in offset lithography a finer gradation of hue is possible than in typography, softer prints are realized but are lacking in sparkle. Tonal range (or the degree of color) is shorter than in typography.

With regard to gravure, in general the dot contour is relatively poor, and the uniformity of ink coverage within the dot is only fair. While this would lead one to expect a limited gradation of hue and a lack of contrast, actually there is a marked sparkle and contrast. Bernstein explains the apparent anomaly by the fact that in gravure, the tonal range is quite short, and the change from high lights to shadows takes relatively only a few steps. As soon as the depth of a unit cell exceeds a certain limit the amount of ink deposited on the paper is too great to indicate much gradation of tonal value. The result is therefore a depth of printing in the solids together with the natural gloss inherent in the inks which yields the characteristic contrast of gravure printing. Because of the short tonal range, gravure is considered by some experts to be inferior to either letterpress or offset.

The Dultgen process of gravure is characterized by variation in not only the depth of cells, but also the size (i.e., area) resulting in longer tonal range as well as in sharpness of dot contours yielding a distinctly superior reproduction.

With the aforegoing summary as a background let us now consider briefly the influence of paper properties on dot distortion. Bekk (*4*) in a series of photomicrographs has shown that with letterpress printing, on a smooth coated paper (Bekk smoothness—1589), as we would expect, the dots were characterized by sharp contours but did show some irregular color density. In the case of a calendered paper (Bekk smoothness—362), the contours were ragged, with completely irregular densities. With newsprint (Bekk smoothness—66), there was very poor dot definition and coverage.

With rougher paper the dot contours are more irregular, and ink is displaced into the nearest surface recesses following the irregular paper patterns. With smooth paper the ink is squeezed out at the periphery of the dot area, resulting in a doughnut effect, yielding sharp contours and sharp reproduction. On rough papers, the sharpness of the contour is lost with an ensuing loss of detail. Also the uniformity of coverage is lost with a consequent loss of gradation of color hue.

The offset process is more tolerant than letterpress of paper roughness of surface, since (1) dot contours are already inherently diffuse due to double transfer; (2) films of 1 to 2 mu are only half as thick as ink films with letterpress, thus are less likely to be displaced under pressure; (3) offset inks are more viscous and thus have greater resistance to deformation; and (4) since the blanket is resilient, printing pressure is more uniform, rather than localized as in typography.

Similarly, ink transfer as related to paper properties depends on the roughness and absorbency of the paper stock. While viscosity and penetration speed of the ink influence the amount of transfer only nominally, the smoother the stock, the less the degree of transfer, and the more rapid the penetration speed, the larger the transfer percentage (*5*).

Percentage of ink transfer while influenced by the paper as one of the factors depends on other details beyond the control of the papermaker such as printing speed and film thickness—and very marginally by temperature and humidity conditions.

Concerning the influence of paper properties on dot distortion and ink transfer, my first experience along this line dates back some 16 years shortly after I started as a neophyte in the paper industry. Our sales manager confronted the technical department with the sobering fact that our respected customers considered the printability of our EF sheet unsatisfactory, and an improvement program was in order. With his hand lens he proceeded to point out the presence of minute pits and craters on the paper surface which he felt had to be eliminated to improve letterpress printability. The paper was analyzed for all known conventional properties, the surfaces studied and photomicrographed at various low power magnifications, and halftone prints made on the proof press.

Our data showed, of course, that the pits and craters are inherent to the very nature of the paper fiber structure, and as regards printability, it was only a matter of the degree of severity of pitting in relation to the fineness of halftone screen of the printing plates. Our studies showed that pitting in our EF papers could be minimized by (1) higher smoothness values through more calendering with lower bulk; (2) more closed and uniform formation; and (3) higher percentage of short fiber stock, more brushing of fiber in the beating and refining stages, and increased filler content.

Photomicrographs of paper surfaces before and after improvement are shown in Fig. 1.

However, with the above solution for the pitting problem we must be aware of the several consequent effects. For instance, if we compress the sheet more by more rigorous calendering, thus increasing the sheet density substantially, what will this do to the critical need for ink receptivity or resilience? Or if we add more clay internally as well as more short fiber, will the strength of our sheet be too low for modern high-speed sheet, web printing, or for its ultimate use in fine textbooks?

Thus we realize at once that the design of the sheet must represent a compromise—strength versus printability—ink receptivity versus smoothness and density. A good portion of the answer to this dilemma lies in coating the surface, a technique which the papermaker has been exploring, de-

Fig. 1. Before—top: After—bottom

Table I. Characteristics of Dot Reproduction in Relation to Various Printing Processes

	Sharpness of dot contour	*Uniformity of ink coverage*	*Over-all results*
Typography			
(1) Usual inks	Good	Poor	Sharpness, contrast, and sparkle good—poorer hue gradation
(2) Cold-set inks	Good +	Poor −	Increase in sharpness, contrast and sparkle—improved reproduction over above
Offset lithography	Poor	Good	Finer gradation of hue possible, softer prints lack sparkle, tonal range shorter than in typography
Gravure	Poor	Fair	One would expect a limited gradation of hue and a lack of contrast actually marked sparkle and contrast, but short tonal range
Dultgen process, in which both the size and depth of dot vary, shows longer tonal range and increased dot contour—superior reproduction to conventional gravure.			

veloping, and perfecting during the past 30 to 35 years. His efforts have ranged from lightly pigmented starch mixtures to coating by various means, even in two-step stages with 6 to 7 lb. per side for each step. With carbonates, clays, or combinations of these two, or other fillers and pigments concentrated on the surface, the problem of ink receptivity is minimized. Also at the same time with the pigment material covering and filling in the surface pits, and craters, nonhomogeneity of the surface can be largely overcome. As a result fine screens (above 120) for highest quality printing can be used in plate making with good dot reproduction and gradation in halftones.

The case for paper coating, however, we will nimbly skip, and allow to rest in the capable hands of those of our friends who are presently engaged in and are more experienced in this large segment of our vast industry.

Before leaving the subject of coated papers, however, and with regard to printability, it might be argued that for equal porosity and smoothness no difference should be expected in the print quality of a coated as against an uncoated sheet. Although we have no data we feel that the difference in surface ink wettability between clay and cellulose is insignificant under conditions existing during the actual printing operation. However, in comparing a coated and an uncoated sheet with equal ash contents, the coated sheet could be expected to yield the best print quality. It is theorized that this would be true because the fibrous portion of the coated sheet would contain less filler than the uncoated sheet, and therefore have greater resilience under printing pressures.

Print through (*6*) which is very undesirable from the standpoint of text legibility and halftone clarity is another topic of equal interest to printer, ink chemist, and papermaker. In this case again the classical approach to understanding this sometimes baffling difficulty is very well set forth in the literature. Print through is defined as the phenomenon which causes a decrease of the surface brightness of the reverse side of a printed sheet, and may occur as shown through or actual strike through.

Differentiation between *show through* and *strike through* is important to the trouble shooter. If a stained or colored oil vehicle penetrates through the paper, "strike through" is said to occur; on the other hand, if the print is merely visible as a result of paper transparency "show through" is taking place. Strike through is usually restricted to inks drying by penetration, and usually takes place when oil-soluble dyes are constituents of the inks. As we understand it, efforts of the ink man have been directed toward such means as elimination of dark vehicle oils and oil-soluble dyes for ink color and adjustments, stressing instead clear oils and pigmented dispersions.

Show through is not always due to poor paper opacity but may occur when the sheet is fairly opaque. Due to the penetration of the oil vehicle in the interspaces between the fibers, this also in relation possibly to printing pressures, the mineral vehicle replaces the air. Since the refractive index of mineral oil bases and paper fibers is about the same, the paper becomes more transparent at the printed spots, causing show through. Show through thus associated with vehicle penetration, i.e., mineral oil vehicles drying by absorption, could be minimized by employing volatile solvents and the higher refractive index drying oils.

A case in point which came up recently in our work involved a 50-lb. uncoated book sheet being printed letterpress. A reputable printing house was struggling with the problem of "strike through," and the printers were of the opinion that low opacity of our sheet was related to the trouble. Simple examination of the returned signatures, using the pen knife erasing test, revealed that the "strike through" was actually show through, not only of the typed matter but especially of the heavy intense black solid illustrations which were printed with such pressure that the images were embossed on the reverse side of our relatively soft wove paper. The printer had run off the entire job stating that the defect could not be noticed until after the ink had dried. Obviously somebody was "holding the bag" on this one.

It was true that the opacity of our sheet was some lower than for a previous printing of an entirely comparable job, which also turned out to be barely acceptable from the standpoint of show through; but at the same time our opacity was up to specification. However, it was noticed that enclosed with the signatures were two 75-lb. lining end-leaf sheets with appreciably higher opacity than the 50-lb. sheet, but which had a similar amount of show through. These simple observations along with our background of lab tests led us to a definite conclusion that the type ink was not right, but also that the paper was not the best selection for this job. The colorless ink vehicle had penetrated the sheet (like a news ink would) increasing the transparency over the printed image area. A meeting of the minds of the printer, inkmaker, and papermaker in specifying this paper and ink for the particular printing job I am sure would have avoided a lot of trouble and saved considerable expense.

Picking of paper during the printing operation deserves some specific mention in our remarks. Picking is a complicated phenomenon under actual printing conditions, occurring in the instant of separation of the ink, plate, paper union. Minute to large areas of the paper surface are disrupted or torn from the sheet. It is described as a complicated phenomenon since in our experience a large number of factors influence the picking tendency. Included in these are tack of ink, printing speed, and thus sheet size (as related to impressions per hour), printing pressure, thickness of ink film (at least marginally), temperature, ink water relations on the press, and the depth and extent of solids areas. These factors in relation to such sheet characteristics as smoothness, density, strength, and bonding forces lead to an immensely complicated maze of interrelated influences. One other especially important related factor must be mentioned and that is the rheology of the printing ink itself. The tack of ink films under conditions of dynamic impact as we know differs widely from its static reaction.

The inkometer developed by Reed (*7*) measures tack or pull required under moving conditions to separate two ink films. Dynamic conditions are necessary due to the thixotropic

(non-Newtonian) characteristics of conventional inks. Picking has been also discussed in terms of energy density of rupture as measured by the rolling cylinder tackmeter. According to the impact vibrational or wave theory, as discussed by Anderson and Steenberg (*8*), paper rupture is considered to occur when the energy density of the impacting wave exceeds the rupture energy density of the paper.

Experimental evidence in this connection reviewed by Voet (*9*) is of academic interest. In this work carried out by means of the rolling cylinder tackmeter, a cylinder covered with a nonabsorbing paper was passed at high speed over a plate covered with a viscous ink causing paper rupture. By inking the cylinder and covering the plate with paper the identical effect was shown. When, however, the cylinder was rolled over a plate covered with inked paper, no rupture occurred at all. This is contrary to the conventional view that the paper in all cases being the weakest link is expected to rupture in all the above instances. In the last of the above experiments described, when the cylinder was rolled over the inked paper, the impact took place in the metal ink interface. Damping occurred in the ink film and dissipated the vibrational disturbance caused by the shock impact before it had reached the ink paper interface. Theoretically, then, no paper rupture was expected, and none occurred.

The demands made upon the ingenuity of the papermaker are often not easy. A case in point that has come up in our work involved an offset sheet to be used for greeting card stock. First, this sheet had to have the usual properties for good lithography including: (1) receptive surface for ink but not water; (2) ink lay-up to bring out brilliance of the colored inks; (3) a high degree of dimensional stability to effect four (or more) color register; (4) moisture content in equilibrium with the relative humidity of the pressroom (the paper must lie flat); (5) minimum of dusting and fuzzing; (6) lack of springiness in the sheet; and (7) sufficient bonding strength in this case to withstand printing speeds of 5000 impressions per hr. on large sheets with high printing pressures and heavy ink application to large solids areas.

Also, for this job the finish had to have tooth for art work to convey the impression of depth of design.

However, in the greeting card industry other operations follow which are equally critical to completing a job successfully, and the sheet must have other special qualities. The paper must be soft and pliable enough to emboss, this in spite of required pick resistance. At the same time it cannot be too limp for die cutting where reasonable firmness and stiffness are necessary. It is very important that the sheet have good folding and creasing characteristics similar to envelope paper. The card may be bronzed involving the application of bronze powder in a glue solution. Here smoothness is desired, and excessive adhesive penetration cannot be tolerated requiring sheet density in addition to sizing to hold out adhesive on the surface. The sheet is then passed through heat to dry the glue and curling cannot be tolerated. Hot and cold gold stamping is done on the sheet requiring good formation.

These various operations plus the conventional requirements of lithography, mean that this sheet if successful, represents a delicate compromise in properties, and allows the papermaker little latitude for tolerances.

Some years ago when we were first "learning" about this same sheet, one of the printers encountered the problem of picking. A visit to his shop showed that the 47 by 67 1/2-in. sheet was being printed at 4500 impressions per hr., at appreciably high pressures, with heavy ink application, on large printed solids areas. A competitor's sheet was tried and was doing a wonderful job as regards pick resistance, ink lay-up, and color brilliance. Our sheet was admittedly much lower in pick resistance by either the Dennison or our rotary Waldron tester than the competitor's paper, but at the same time generally conformed to the accepted specifications. Believing that this was another special case definitely requiring more pick resistance in the sheet due to the speed, pressure, solids, etc., it seemed natural that we should build more bonding strength into this sheet. However, only several days later we heard from the customer, and the story had changed. When the printed sheets of greeting cards were being run through the folding operations, our sheet performed well, while the too hard competitor's paper gave a ragged uneven crease and tended to buckle, being entirely unsatisfactory for the job.

In conclusion I wish to thank all of you for bearing up splendidly under this lengthy lament on the troubles of a "beat-up" papermaker which actually we might entitle "So *You* Think *You* Have It Tough, Mr. Printer or Mr. Inkmaker."

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Lake States

The fifth meeting of the Lake States Section of TAPPI was held at the Conway Hotel, Appleton, on April 12, 1955. Approximately 125 people were in attendance.

The meeting was devoted to presentation of the C. J. West Award papers. This award has been established by the Lake States Section as a memorial to C. J. West in recognition of his long and illustrious service to the paper industry. The purpose of the award is to encourage young technical men in the paper industry to undertake and report on suitable investigations. Limitations are (1) maximum age of 35 years; (2) the candidate shall not have presented or had published a paper by TAPPI; (3) the participant shall not be employed in a supervisory position; and (4) the paper shall deal with a scientific, technical, or engineering phase of the pulp and paper industry.

Of the papers entered in competition for this award, the following five were selected for recognition:

1. "On a Device to Measure Surface Profiles or Slice Opening with Applications to Basis Weight Problems," by William H. Cuffey, Kimberly-Clark Corp.
2. "An Investigation of the Freeness and the Index of Fiber Length Tests," by F. P. Lodzinski, Whiting Plover Paper Co.
3. "Soil Filtration Studies on Spent Sulphite Liquor," by J. Marshall Buehler, Nekoosa-Edwards Paper Co.
4. "Laboratory Ink Drying Time Tests with Letterpress Inks and Papers," by Norman J. Beckman, Kimberly-Clark Corp.
5. "Photographic Techniques for Paper Surface Study," by John C. Nelson, Fox River Paper Corp.

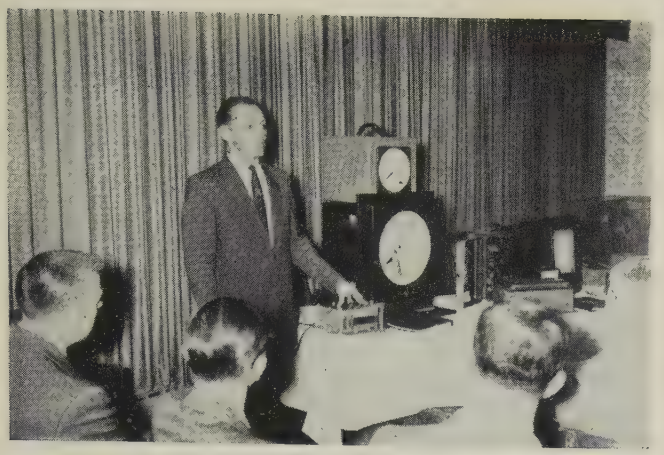
Each of these participants was given the book "Pulp and Paper, Vol. I," by James P. Casey. Norman Beckman was judged the winner of the C. J. West Award and was given a check for $50 in recognition of his presentation.

JOHN W. BARD, *Secretary*

Pacific

Pacific Section of TAPPI held its annual Shibley Award meeting at Everett, Wash., on March 4, 1955, with an attendance of approximately 114.

Fred Weleber, past-chairman of the Pacific Section, had charge of this meeting and served as moderator of the afternoon presentation of Shibley Award papers. The following four papers were presented. They are published in this issue.



Walter Mikelson, General Electric Co., speaking at the April meeting of the Kalamazoo Valley Section

1. "Rapid Method of Determination of the Alpha Cellulose Content of Pulp," by Kenneth A. E. Blackmore of Puget Sound Pulp & Timber Co., Bellingham, Wash.
2. "Paper Handling at the Trimmers," by John V. Gould, Everett Pulp & Paper Co., Everett, Wash.
3. "A Simple Test as an Aid in the Control of Brown Stock Washing," by John Griffith, Crown Zellerbach Corp., Camas, Wash.
4. "Unique Structural Treatment Feature in New Filter Plant," by Don Wooden of Weyerhaeuser Timber Co., Pulp Div., Everett, Wash.

Following this meeting a social hour was held at approximately 6:00 p.m. followed by dinner at the Everett Elks Club. After dinner, Mr. Weleber presented Kenneth A. E. Blackmore and Don Wooden with $50 checks as co-winners of the Shibley Award contest. All four contestants were presented autographed copies of Sutermeister's textbook. Following this presentation, Dean Lloyd S. Woodburne, Dean of College of Arts and Sciences, University of Washington, Seattle, Wash., spoke to the group.

H. B. Petersen, *Secretary-Treasurer*

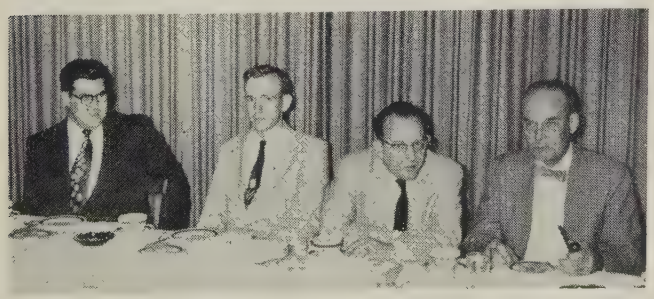
Kalamazoo Valley

More than 100 persons attended the annual engineering meeting of the Kalamazoo Valley Section, Technical Association of the Pulp and Paper Industry, held April 7, 1955, at the Hotel Harris.

Members of the Kalamazoo Section of the Instrument Society of America were guests. Samuel B. Hastings, president of the ISA, said that since his group was particularly interested in automation, it was a special privilege to attend the meeting.

The principal speaker, Walter Mikelson, of General Electric Co., demonstrated and discussed new measuring and indicating devices for the paper industry. He also showed some adaptable to automatic control of paper machines. Mr. Mikelson used slides to illustrate his demonstrations.

Special interest was shown in the following devices.



Lawrence Bortolotti and Leonard Timmer, Western Michigan College students; Paul Applegate, treasurer; and L. D. Nicolson, new president of the Michigan Paper Co. div. of W. C. Hamilton & Sons

P. D. Applegate, Hercules Powder Co.; D. B. Gearhart and Walter Mikelson, General Electric Co.; J. A. Dean, Michigan Paper Co.; S. B. Hastings, Instrument Society of America; and R. T. Trelfa, Watervliet Paper Co.

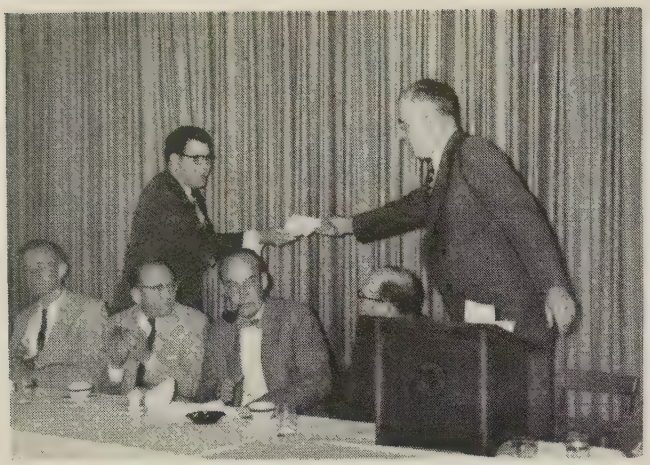
1. A vibration meter particularly sensitive to acceleration. It can indicate the approach of bearing failure.
2. A similar type of device, modified so as to be sensitive to impact, which has been successfully used in a number of applications. It detects the presence of lumps, calender creases, etc., in paper, at the same time ignoring bearing and floor vibrations. It will detect lumps as small as 0.003 in. in height.
3. A device to measure the thickness of stainless steel linings inside of pulp digesters.
4. Tachometer generators of great precision for measuring "draws" (speed differentials) between sections of paper machines.
5. A tensiometer which measures and controls tension of the paper at the dry ends of paper machines. Best control of machine draws is accomplished by tachometers at the wet end and the tensiometer at the dry end, the speaker said. This latter practice imitates the papermakers' practices of patting the dry sheet, and, as shrinkage of the paper varies, it automatically changes speeds of the drier sections.
6. A moisture-monitor, based on the principle of capacitance, which gives exceptionally good control and which is unaffected by static in the paper.
7. Beta-ray gages which employ radioactivity to measure the weight of a sheet of paper while it is being made.
8. A turbidimeter which can be used to measure the consistency of paper stock and of the other suspended materials in the usually unmeasurable range of 0 to 1%.
9. A pinhole detector useful on blueprint and coated papers.

The speaker was introduced by David B. Gearhart, Kalamazoo manager of apparatus sales for General Electric. James A. Dean, chairman of the Kalamazoo Valley Section, presided.

May Meeting

Lawrence Bortolotti, Kalamazoo, Mich., paper curriculum student at Western Michigan College, was presented with a

E. K. Stilbert, Dow Chemical Co.; J. A. Dean, chairman; R. T. Trelfa, vice-chairman; and R. T. Elias, secretary; at the May meeting of the Kalamazoo Valley Section



Lawrence Bortolotti receiving scholarship from J. A. Dean, chairman of the Kalamazoo Valley Section

$100 scholarship in recognition of having led his junior class in scholarship, at the Student Recognition Dinner of the Technical Association of the Pulp and Paper Industry May 5. Present at the Hotel Harris, Kalamazoo, for the dinner were 70 members and guests.

Presentation of the award was made by James A. Dean, section chairman of TAPPI. The dinner was designed as an expression by TAPPI of its interest in the young mem coming into the paper industry.

Robert T. Elias, associate professor in the Paper Technology Department, presented five senior students of the department. Each reported on progress of his thesis, work required of all seniors in the technical paper courses.

Lester Beeman, Otsego, Mich., reported experiments in which it was found possible, by means of flotation techniques, to separate ink pigments from the clay and fibrous materials in deinking wastes.

Donald V. Martin, Kalamazoo, spoke of studies in the fundamentals of supercalendering. He reported similarities between the internal effects of rolling pressure and those of flat pressing.

Ronald C. Morgan, Kalamazoo, described a procedure which promises to make more rapid and accurate the evaluation of decay-resistant wrappers such as are used for protecting military supplies.

The making of strong papers in which the fibers are 100% glass and the binders, wet-strength resins, was described by Kenneth C. Rasmussen, Muskegon, Mich.

The chemicals and cooking conditions used in commercial deinking of waste papers have deleterious effects upon the strength properties of fibers, Leonard J. Timmer, Kalamazoo, told the group.

Western Michigan College students who spoke at the May meeting of the Kalamazoo Valley Section: Ronald Morgan, Lester Beeman, Leonard Timmer, Kenneth Rasmussen, and Donald Martin

Final speaker was Elmer K. Stilbert, assistant manager of the Coatings Technical Service, Dow Chemical Co., Midland. His talk was on "From Senior to Junior in Three Easy Lessons."

In a humorous way, with the aid of projected cartoons, the speaker portrayed adjustments which a graduate must make in becoming an accepted member of the industrial team. The graduate is sometimes inclined to expect too much opportunity right at the start to show what he can do, the speaker declared. Industry is often at fault in not facilitating the "breaking-in," he said.

Some training programs could be improved to more quickly take advantage of the training which new men have received, the speaker declared.

He concluded with twelve bits of advice for young men who "wish to be left out of the competitive struggle for promotions." These ranged from "Don't look ahead and make plans" to "remember all your associates are out to 'knife' you."

R. T. Trelfa was program chairman.

ROBERT T. ELIAS, *Secretary*

Chesapeake and Allegheny Pulp and Paper Club

The fourth meeting of the Chesapeake and Allegheny Pulp and Paper Club, held at the National Bureau of Standards in Washington, D. C., on March 25, featured a symposium on the preservation of record papers, a demonstration run of glass-fiber paper in the Bureau's experimental paper mill, and an address by W. T. Diefenbach, Bureau of Engraving and Printing, on "Modern Printing Inks."

The symposium was conducted by George Smith, Library of Congress. James Gear of the National Archives discussed current preservation practices at his agency. Various steps in the treatment of archival records from sterilization upon receipt to repair by lamination were described. Records of the National Archives are kept in an air-conditioned building, and the air is washed to remove sulphur dioxide. Fragile and damaged documents are usually strengthened by laminating between sheets of cellulose acetate film.

Leon de Valinger, Jr., state archivist of Delaware, described his experiences in setting up and operating a program of testing paper and other writing materials for use in state and county offices. Some of the pitfalls in operating such a program were pointed out, and the great benefit to be derived from a testing program was emphasized.

Joseph H. Flynn of the National Bureau of Standards discussed the irradiation of paper with ultraviolet light. The paper was prepared from purified cotton, thoroughly dried in a vacuum at 95°C., and exposed to 2537 A radiation. Analysis of the gaseous products of irradiation showed that carbon dioxide, carbon monoxide, and hydrogen were produced. Analysis of the irradiated paper showed increases in aldehyde and carboxyl content, and decreases in degree of polymerization.

Lewis S. Reid of the Metropolitan Life Insurance Co. discussed trends in the use of different types of papers for long-life records. Using various physical tests as a basis, specifications for various papers were set up 15 years ago, and the performance of these papers has been used as a basis for revision of specifications. The importance of a good specifications-testing program in order to obtain papers of the desired quality was emphasized.

Mr. Diefenbach said that ink and paper research men were now cooperating to develop materials that would go well together in modern high-speed printing, whereas formerly the inkmaker had the burden of producing inks that would be suitable for various papers. He described recent progress in

At the March meeting of the Chesapeake & Allegheny Pulp & Paper Club: John Symes, chairman, National Container Corp.; W. T. Diefenbach, Bureau of Printing & Engraving; R. G. Macdonald, TAPPI; and C. E. Libby, North Carolina State College

the use of heat-set inks, which were used in press runs at 900 f.p.m. in 1947, but are now used at 1500 f.p.m. Heat setting is accomplished by passing the printed paper over drums at 325°F., with air jets at 600°F. The paper manufacturer must therefore provide a paper that is not brittle under these conditions.

In the moisture-setting or precipitation process, a jet of steam is used to dilute the glycol in the ink. This causes it to penetrate into the paper and precipitate the pigment on the surface. Steam at temperatures from 700 to 1000°F. may be used for this purpose. Moisture-set inks are particularly useful for waxed papers and board, said Mr. Diefenbach, since the wax treatment has a bad effect on ordinary oil inks. Glycol, on the other hand, is not miscible with hot paraffin. With board or carton stock there is often enough water in the stock to set the ink without using steam. Several difficulties in using moisture-set inks have been overcome. The precipitated inks would dry with a matte finish as compared with oil inks; the use of dyes, zinc resinate, and some phenolic resins improves the gloss. Slow setting can be hastened with steam up to 1000°F. Corrosion of the presses from water in the glycol and acid in the rosin is overcome with inhibitors, such as triethanolamine. Inhibitors affect some colors, so that a special list of pigments suitable for water-set inks is used. Stabilizers are used to prevent precipitation on the press due to summertime high humidity.

Considerable progress in new formulations for oil inks was made during the war, when linseed oil was in short supply. Soybean oil, fish oil, castor oil, and petroleum oils with drying properties have been successfully used.

Magazine inks are mostly of the heat-set variety. Resins are used in mineral oil that evaporates slowly at room temperature but rapidly at elevated temperatures. The resin is dissolved in mineral oil and treated with lime. This gives a colloidal suspension with less after tack when the vehicle soaks into the paper. To get increased dryness in the sheet, waxes have been added to the ink, and more recently, polyethylene. Increased pigment content also gives quicker drying. Undesirable thixotropy is overcome by adding such materials as gilsonite or aluminum octoate or stearate gels. For high speeds with such inks, a thicker paper is required.

Mr. Diefenbach touched on gravure inks, which were originally gilsonite in a coal-tar solvent, but now make use of limed rosin, nitrocellulose, and ethyl cellulose. Such inks can print readily at 1000 f.p.m. Aniline inks, particularly useful for food wraps, cellophane, and cartons, were also mentioned. Originally a shellac-alcohol-dye formulation, aniline inks now use such constituents as amberol and other synthetic resins, ethyl acetate, and pigments. These inks have always printed solids well, but have not been very satisfactory for halftones. Recently good experimental results have been obtained with a 120-line screen.

A new development is plastisol ink. Polyvinyl chloride is ground fine in oil. When heated, it takes up the oil as a plasticizer, and dries to a very scuff-resistant condition. Inks of this type are used for pictorial covers of better magazines. However, the fact that the ink cannot be saponified prevents reclaiming the waste paper, and as consequence its use is limited.

Another idea that has found limited application is printing with a hot ink that would congeal when it hit the paper. A formula containing staybelite resin and microcrystalline wax has been used. Difficulties have been that both sides of the sheet could not be printed at the same temperature, because of the softening of the side first printed by the heat from the second side. Furthermore, waste paper printed with hot inks is not readily reclaimed.

Current research is enlisting the cooperative efforts of the papermaker, the inkmaker, and the printing press engineer, and Mr. Diefenbach predicted accelerated progress as a result. Among the interesting fields of research he mentioned reactions between a component of the paper with a substance in the ink, and the development of printing speeds up to 2000 f.p.m. Static electricity may be a very serious problem at such speeds, as the ink tends to jump to the paper instead of being pressed into it, with resulting fuzziness and linear distortion of the print. Papermakers may well be concerned with this problem.

Eighty-nine members of the club and visitors registered for the different parts of the program, which was arranged by Mr. W. K. Wilson of the National Bureau of Standards, who acted as local program chairman for the club.

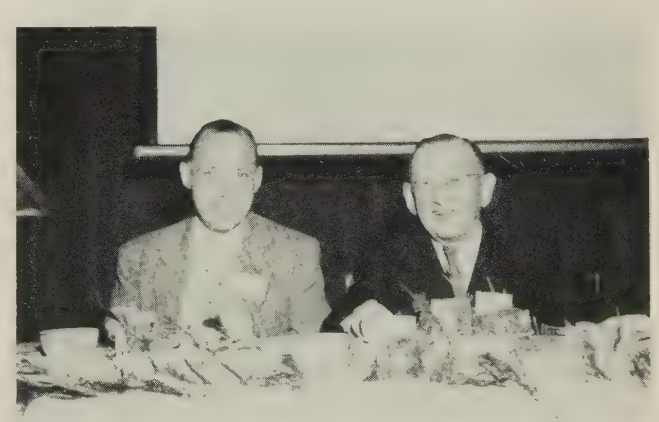
John Symes, National Container Corp., who is chairman of the club, announced that its next meeting would be held on May 20 in Fredericksburg, Va. The program, being arranged by G. W. Renninger of American Viscose Corporation, will include a dinner meeting at 6 o'clock at the Princess Anne Hotel, an address on the fine structure of cellulose in dissolving pulps by O. A. Battista of the Marcus Hook, Pa., laboratory of American Viscose, and the annual business meeting. ROBERT B. HOBBS, *Vice-Chairman*

Southeastern

The Southeastern Section of TAPPI met at the George Washington Hotel, Jacksonville, Fla., March 18–19, 1955.

About 160 members and guests registered for the program which began with the social hour at 6:00 p.m. and dinner at 6:45 p.m.

Mr. Pineo, Section chairman, introduced R. S. Hatch, vice-president in charge of research, Hudson Pulp & Paper Co. Mr. Hatch welcomed the group for the host mill, his company's



M. B. Pineo, Brunswick Pulp & Paper Co. and R. S. Hatch, Hudson Pulp & Paper Co.

plant at Palatka, Fla. He invited the group to visit the mill on Saturday morning.

W. C. Chapman, program chairman, was in charge of the technical program which consisted of four papers.

The paper prepared by David Wetherhorn, "Reduction of B.O.D. Load from the Mill of Southern Paperboard Corporation by Balancing and Improving the Recovery System," was presented by J. H. Smith.

Mr. Smith described what can be done with the necessary equipment when properly operated.

The mill has two sewers: A carries the effluent from the caustic area and the recovery room including the barometric leg and dirty condensate of the evaporators, amounting to about 9 to 12 million gal. per day. B carries the pulp and paper effluent varying in an amount from 5 to 9 million gal. per day.

Initially, a survey showed a 5-day B.O.D. per ton of 46.5 for A and 108.9 for B. By installing and properly operating the necessary equipment such as another line of vacuum washers with filtrate tanks and foam towers, a second set of sextuple effect evaporators of equal capacity to the first, another green liquor clarifier and additional storage tanks balancing an expanded production of 625 tons per day according to a survey preceding the presentation of the papers the B.O.D. load was reduced to 8.5 lb. per ton in A and 18.0 lb. per ton in B. The average pounds B.O.D. per ton after amounted to 35% of the one before expansion or to a decrease of the pollution load by 58% accompanied by a 19% increase in production.

W. B. Roberson of Hudson Pulp & Paper Co. at Palatka presented a paper on "Two-Slice Headboxes for Fourdrinier Machines."

Mr. Roberson described a second slice, in addition to the conventional one, which was placed in approximately the same position as the rectifying roll immediately preceding the conventional slice, both slices being 6 in. apart, while this rectifying roll was moved back, practically touching the secondary slice.

Two grades of paper were selected for the test runs: a 70-lb. wrapping and a 60-lb. bag.

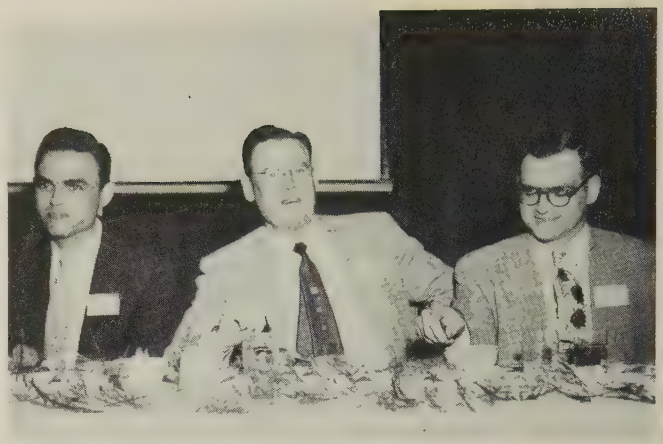
Best results were obtained by setting the first slice with a gap of about 6 in. and the second with the usual opening of about $1^3/_4$ in. If the first slice was set at a greater gap a decrease in machine direction tensile and burst resulted. A lower than 6-in. gap setting lowered the cross direction tensile.

Bursting strength on the 70-lb. wrapping increased from 61 to 70: MD tensile from 45 to 52 by adding the additional baffle or slice. On the 60-lb. bag burst was increased from 51 to 61: MD tensile from 41 to 47. The sum of MD and CD tensile increased with the additional headbox.

Increased bursting strength is partially the result of the increased MD tensile.

It was known from previous investigations that a decided

C. L. Smith, National Container Corp.; J. S. Moore and C. G. Kimble, Union Bag & Paper Corp.



J. H. Smith, Southern Paperboard Div.; C. N. Rogers, Sonoco Products Co.; and W. M. Ackerman, West Virginia Pulp & Paper Co.

increase in total tensile and bursting strengths can be obtained by placing two rectifying rolls in or immediately back of the single slice in place of the conventional single rectifying roll. However, the two-slice headbox, by proper setting of the secondary slice, aligns fibers in the machine direction which in turn builds up MD tensile, of decided advantage for twisting or creping kraft. On the contrary where CD tensile is important, such as on multiwall, the system of two rectifying rolls is of greater advantage than a two-slice headbox.

It is possible to obtain burst tests which approach within 15% those obtained on handsheets when a two-slice headbox is used (compared to 30% difference in the conventional set-up).

John S. Moore of Union Bag & Paper Corp. gave a very interesting discussion of "Rate of Moisture Gain or Loss in Kraft Paper or Board."

Mr. Moore pointed out the importance of the moisture content of paper as related to the physical qualities and the test values obtained. It is not enough to give test results, such as bursting strength and tensile, but the conditions of humidity and temperature should be known if the data are to mean much. Paper or paper board will reach an equilibrium moisture content in a fixed temperature and humidity environment, but the point of equilibrium is dependent to a degree on the direction from which it is approached, i.e., wet or dry. The importance of this hysteresis phenomenon is recognized by TAPPI in the standards for testing paper.

The principal speaker of the evening was Robert B. Hobbs, chief, paper section of the National Bureau of Standards.

We were indeed fortunate to have Mr. Hobbs who talked more or less informally on the subject of "Paper Research at the National Bureau of Standards." His discussion centered around a series of slides illustrating equipment in use and the functions of his section at the Bureau.

Two-Slice Headboxes for Fourdrinier Machines

W. B. Roberson

Papermakers generally agree that some of the most important characteristics of paper made on a fourdrinier machine are determined or limited by the design of the headbox and slice and the wet end of the machine. The degree of dispersion, orientation, and motions of fibers as they leave the slice and go on the wire have a direct bearing on the formation of the finished sheet. Formation affects such physical characteristics of paper as tensile, bursting strength, fold, porosity, etc. Basically, the function of a headbox is to spread the pulp suspension uniformly across the width of the machine and deliver the pulp suspension to the slice,

W. B. Roberson, Hudson Pulp and Paper Co., Palatka, Fla.

N. A. Jacobson and W. M. Ackerman

thoroughly and uniformly mixed, with a minimum of turbulence at a speed consistent with the speed of the machine.

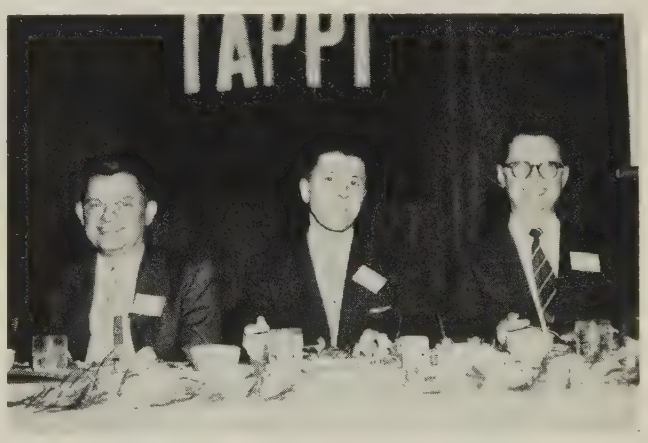
Many consumers of kraft paper consider burst and tensile the most important physical tests obtained on kraft papers. Some customers are willing to pay premium prices for certain grades of kraft paper with a "100% Mullen," other customers (*1*) consider a high or low burst to be the major difference between the various grades of kraft wrapping paper. Phillips (*2*) states that "From the theoretical standpoint the optimum in good formation and strength properties is secured in the random oriented handsheet." In actual practice it is not practical to make a sheet on the paper machine that has the physical tests which can be obtained by making handsheets from the same pulp on a handsheet mold. It is possible to make handsheets from refined southern kraft pulp obtained at the machine regulating box that will have a bursting strength of 115% while the same pulp run over the paper machine with the usual headbox will have a burst of only 80%. Part of this difference is due to handsheets having a higher stretch than paper made on a paper machine. This does not, however, account for all the differences obtained.

The use of the two-slice headbox is probably almost as old as the fourdrinier machine. Papermakers were quick to realize the effectiveness of such a headbox for evening the flow across the machine and for giving agitation to break up fiber flocs and bundles just before it was admitted to the wire. Some old fourdrinier machines are equipped with headboxes which have two or more slices which extend over the wire. One type of the Van De Carr slice, of which there are several kinds, does not use a rectifying roll immediately preceding the slice that admits stock to the wire, but depends upon flow eveners and a hump in the bottom of the headbox to promote fiber distribution and hinder flocculation. The patent literature describes a number of headboxes which have more than one slice. A recent patent (*3*) describes a headbox with four rectifying or distributing rolls and four adjustable baffles or slices, two of which follow the last rectifying roll. A headbox similar to that used in these experiments has been briefly described by Kutter (*4*). The two-slice headbox is usually regarded as a headbox for specialty papers but this is not necessarily true since recent paper machine headbox patents (*5*) favor this type of design.

The relative speed at which the pulp suspension and the paper machine wire are moving at the instant the sheet is being laid down on the wire can materially affect the strength characteristics of the sheet as is well known by papermakers. As a matter of fact in a large portion of the paper made in the south the fiber is dragged onto the wire. The theoretical speed of the pulp is usually about 90 to 95% of the actual wire speed. The hydraulic principle and some theories regarding stock movement were discussed by Lund (*6*) in his paper entitled "Hydraulics and Paper Machine Sheet Formation."

Since in most grades of kraft paper the fibers are dragged on the paper machine wire to increase fiber orientation in the machine direction and therefore increase such tests as burst, it is obvious that if a headbox is designed so that fibers can be aligned in the machine direction it would be of decided advantage. On many grades the machine tender cannot drag a sheet on the wire to the extent he would like. Excessive dragging of the sheet on the wire tends to disrupt the formation and it becomes "wild." Best formations are obtained when the sheet is formed even with the wire speed.

The headbox used in this series of experiments was of the open type equipped with only one rectifying roll immediately preceding the slice. Other rectifying rolls were used in the stock inlet to the headbox. The slice placed in the headbox was adjustable in a vertical direction only and was essentially a straight edge slice with the lower edge, under which all of the pulp suspension passed, rounded off to eliminate stock hanging on the slice. The additional slice was placed in approximately the same position as the rectifying roll immediately preceding the slice that admitted stock to the wire so that the slices were about 6 in. apart. The rectifying roll immediately preceding the slice that admitted stock to the wire was moved back so that it was practically touching the secondary slice. There was nothing between the slices. Two slice headboxes normally use a rectifying roll immediately back of the secondary slice as an aid to controlling fiber distribution across the machine. On relatively high speeds this is necessary. On low speeds this is not essential. Precautions were taken to insure that all machine settings were maintained as uniformly as possible. Machine speed, stock freeness, machine headbox consistencies, head in machine headbox, wire pit temperature, and numerous other settings and variables were maintained the same as near as possible for the two parts of the experiment, that is, with a one slice and a two slice headbox. A shake was used on the fourdrinier wire section on both parts of the experiment. Two grades of paper were selected for the series of tests run: 70-lb. wrapping and 60-lb. bag. It was found on these two grades that best results were obtained by setting the first slice with a gap of about 6 in. and the second slice with the usual opening of about $1^3/_4$ in. If the first slice was set with a gap greater than 6 in. there was a decrease in MD tensile and burst. Openings lower than 6 in. lowered CD tensile tests which were not desired in these grades. Tests obtained are shown in Table I and these are believed to be typical of what can be obtained with such headboxes. Bursting strength on the 70-lb. wrapping sheet was increased from 61 to 70 MD tensile from 45 to 52 by adding the additional baffle or slice to the headbox. Bursting strength on the 60-lb. bag sheet was increased from 51 to 61 and MD tensile from 41 to 47. Other tests were not greatly affected. It is of interest to note that the sum of the MD and



W. B. Roberson, Hudson Pulp & Paper Corp.; R. B. Hobbs, National Bureau of Standards; and J. S. Moore, Union Bag & Paper Corp.

CD tensile increased with the two-slice headbox. All conditioning and testing of paper was done in accordance with TAPPI specifications. Tests on wrapping represent average tests obtained over a 24-hr. period of each part of the experiment. Tests on bag represent average tests for an 8-hr. period. Dividing the headbox into two compartments with the baffle resulted in two different levels of pulp suspension. The stock level between the two slices was lower than the stock level in the compartment where the stock was admitted to the headbox. In some cases this difference was 12 in. or more. In general, if the stock level in the two compartments were the same no difference was noted in the finished sheet from that produced with a one-slice headbox.

The increased bursting strength is partially the result of the increased MD tensile, since "Mullen depends in a complicated way on the machine direction tensile strength and stretch" (*7*). Uniformity of formation is probably an additional factor involved in kraft sheets. With an extremely wild formation it would be theoretically possible to obtain a relatively high MD tensile and yet have a low burst since the mullen tester is designed to hunt for weak spots in the sheet. The fact that current trade practice does not grade kraft wrapping and bag on any other basis than bursting strength makes it possible, by means of a secondary slice, to grain a sheet in the machine direction and therefore increase MD tensile and burst at the expense of MD tear and CD tensile.

The effect of two-slice headboxes was studied by Moss and Bryant (*8*) with the aid of a photographic method used by Prandtl. They concluded that the distribution of fibers in a moving stream is nearly random. The random distribution is broken up, however, as the fibers are speeded up under the slice where the accelerating motion tends to pull the fibers into alignment with the streamlines. It was shown photographically that a secondary slice has a strong tendency to elongate and break up fiber flocculation. They also found that the two-slice headbox not only provided agitation for uniform dispersion and to even up the flow across the machine, but also extended its agitating effect to the stock on the wire by means of gentle eddies still remaining in the stream after the slice. Lund (*5*) has postulated a theory which was substantiated by photographic work of Moss and Bryant that a pulp suspension passing under a slice causes a velocity gradient between layers of the stream from the slice, the highest velocity gradient between layers of the stream from the slice, the highest velocity being at the top and the lowest at the bottom. This factor probably has an important bearing on the agitation received by the pulp suspension between the two slices. Kutter (*4*) carried out a series of experiments with a two-slice headbox. He reported that such headboxes are satisfactory and present a much more simplified control problem. He was able by use of the secondary slice to eliminate streaks and lumps which he was not able to eliminate with a conventional one-slice headbox.

One of the disadvantages possible in a two-slice headbox is a lack of control of fiber distribution across the machine. The slice lip can be set to give correct distribution across the machine for a given head in the headbox, but unless the slices are correctly designed and spaced, the fiber distribution across the machine will not be the same when the head is changed to a higher or lower figure. This could necessitate a readjustment of the slice lip on extreme weight changes.

Some papermakers believe the distance between the slices should not be more than 6-in. For very low speeds this would probably be satisfactory. For relatively high speeds, however, this distance between slices could possibly be increased and still obtain results similar to that described in the foregoing. The adjustment of the distance between slices has been proposed as an aid to controlling sheet formation (*9*).

One equipment manufacturer (*10*), who has carried out research work on paper machine headboxes, has found that a rectifier roll creates a zone of disturbance downstream for a distance of approximately the diameter of the roll. If a rectifier roll is placed too close to the slice, this cone of disturbance will follow through to the slice. Two rectifier rolls arranged in an arc about the slice opening get the rolls far enough away from the slice to allow the disturbance to blend and die out before the stock leaves the slice. It has been found by actual machine operation that a decided increase in total tensile and burst can be obtained by placing two rectifying rolls in an arc immediately back of the slice in place of the usual single rectifying roll. On some grades this amounts to as much as 10% difference on tensile tests. This, in many respects, approximates the action of a two-slice headbox. The two-slice headbox, however, can be used by proper setting of the secondary slice to align fibers in the machine direction and therefore build up machine direction tensile which on certain grades is a decided advantage. On some grades such as twisting kraft or creping which require a very high MD tensile the two-slice headbox is essential. Some grades of light weight tissue also require the tensile strength to be concentrated in one direction in order to minimize breaks on the paper machine. On other grades, such as multiwall kraft which is run with a high CD tensile it is questionable if such a headbox is of value, when compared with a headbox which has two rectifying rolls preceding the slice that admits stock to the wire. It has been stated (*11*) that there is no difference in a double and single slice at speeds over 500 f.p.m. This statement is perhaps true for certain types of pulp, but on kraft pulp there is a difference at speeds considerably in excess of 500 f.p.m.

Table I

	One-slice headbox	*Two-slice headbox*
Grade—Kraft Wrapping 70-lb.		
Basis weight (24 × 36–500), lb.	70.3	70.0
Bursting strength, p.s.i.	61	70
Tear		
MD g./16 sheets	158	152
CD, g./16 sheets	165	171
Total	323	323
Tensile		
MD (1-in. strip)	45	52
CD	29	28
Total	74	80
Grade—Bag		
Basis weight (24 × 36—500), lb.	60.4	60.0
Bursting strength, p.s.i.	51	61
Tear		
MD, g./16 sheets	135	126
CD, g./16 sheets	145	150
Total	280	276
Tensile		
MD (1-in. strip)	41	47
CD	24	23
Total	65	70

In conclusion, it may be said that a two-slice headbox improves certain physical tests of paper such as bursting strength and machine direction tensile without unduly affecting CD tests. This difference is obtained by graining the sheet slightly in the headbox before it is laid down on the wire. On many grades of kraft bag and wrapping the secondary slice if properly handled can increase burst and MD tensile with almost no loss in CD tensile and MD tear. In many respects approximate those obtained by arranging two rectifying rolls in arc about the slice. It is possible to obtain burst tests that approach within 15% of those obtained on handsheets with a two slice headbox, compared to a difference of about 30% with some one-slice headboxes.

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The author wishes to acknowledge the advice and suggestions of R. S. Hatch in the preparation of this paper.

Empire State (Central District)

The Senior Students in the Department of Pulp and Paper Manufacture at the New York State College of Forestry were the guests of TAPPI at the Central New York District meeting held May 6, in Syracuse.

Chairman F. W. O'Neil called the meeting to order. There were 79 in attendance. Ralph Prince, treasurer of Empire State Section of TAPPI, expressed his pleasure in the fine turnouts for the Central New York meetings. Empire State Chairman Fred Sommerville hoped that as many as possible would attend the Whiteface Inn meeting June 9, 10, and 11.

Senior students in the Dept. of Pulp and Paper Technology, State University of New York, College of Forestry, Syracuse, N. Y. Left to right: W. H. Trice, F. J. Fargomeli, Jr., J. E. Schad, H. M. Greenhouse, D. W. Ferguson, J. F. Connelly, R. C. Johnson, J. M. Harper, R. E. Lee, K. Goodwin, S. D. Costanzo, and J. A. Cheesman

Professor O'Neil introduced the newly elected officers and expressed his thanks to all who had helped to make the year a success.

Benjamin P. Burtt, associate professor, Chemistry Department, Syracuse University, was the guest speaker. Professor Burtt, who is also chief of radiological chemistry for Syracuse Civil Defense, entertained all with his very humorous dissertation, complete with surprising experiments, the "Unique Properties of Dihydrogen Oxide."

The current season will be climaxed with a dinner dance on June 3 at the University Club in Syracuse.

(Mrs.) Barbara H. Wortley, *Secretary*

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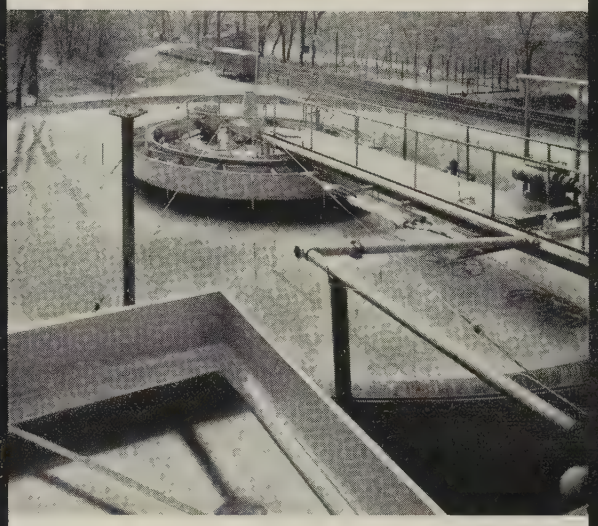

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SHIBLEY AWARD PAPERS 1955

Pacific Section, Everett, Wash., March 4, 1955

A Rapid Method for the Determination of Alpha-Cellulose in Pulp

KENNETH A. E. BLACKMORE

Cross and Bevan first defined alpha-cellulose in 1904 as that portion of the cellulose insoluble in 17.5% NaOH under certain very specific conditions. Their method of determining alpha-cellulose was recommended by the Division of Cellulose Chemistry of the American Chemical Society in 1929, and a modification of the method was tentatively approved by the Technical Association of the Pulp and Paper Industry in 1931 (*1*). A determination by this method requires at least 55 hr. for completion. Because it is frequently necessary in the production of chemical grades of wood pulp to know the alpha-cellulose content of the pulp without this delay, many mills have developed modifications of the TAPPI method. These modifications usually result in an analysis requiring only 6 to 7 hr. However, it is frequently of great advantage to know the alpha-cellulose content of pulp at various stages of production without even this 6 to 7 hr. delay. This information is especially useful when the grades are changed, or when the bleaching process is accidentally interrupted. Such situations often result in the production of off-grade pulp much of which could have been prevented had the alpha-cellulose content of the pulp been known earlier. It was therefore the purpose of this investigation to develop a more rapid procedure which would give results comparable with those obtained by the longer methods.

The TAPPI method for the determination of alpha-cellulose in pulp consists of three main operations:

1. The most time-consuming operation is sample preparation. The sample is dried, disintegrated into an open "fluffed" form, and conditioned in this state for 48 hr. Several 3-gram samples of this conditioned pulp are weighed for alpha-cellulose and moisture determinations.

2. The second operation is the maceration of the prepared and weighed samples with 75 ml. of 17.5% NaOH followed by mercerization at 20°C. for a total time of 45 min. The mercerized pulp slurry is diluted with 75 ml. of water, filtered and washed, the alpha-cellulose being retained as a pad in a perforated bottom Gooch crucible.

3. The final operation is the determination of the exact weight of the alpha-cellulose pad and involves a drying period of 6 hr. at 105°C., followed by cooling for 30 min. in a desiccator prior to weighing. The per cent alpha-cellulose is then calculated from the oven-dry weight of the alpha-cellulose pad and the estimated oven-dry weight of the pulp taken for the analysis.

Two modifications of the TAPPI procedure have been adopted by most manufacturers of pulp. One specifies the use of machine-dried pulp cut into 1/4-in. squares and eliminates both the fluffing of the sample and the 48 hr. conditioning period. The other substitutes a coarse fritted glass funnel for the perforated bottom Gooch, making filtration more convenient and less time-consuming. These modifications result in a procedure requiring about 6 hr. for the analysis of the machine-dried sample or about 22 hr. for a sample of slush pulp. The method modified in this manner gives results comparable with those obtained by the TAPPI method, and is referred to in this paper as the standard procedure.

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PROCEDURE

Initial investigations were devoted to the two most time-consuming operations: the preparation of the sample prior to analysis, and the accurate determination of the oven-dried weight of the alpha-cellulose pad.

Although the standard procedure permits the immediate use of machine-dried pulp cut into 1/4-in. squares, the analysis of slush pulp introduces the problem of drying the sample, a step requiring about 16 hr. It was reasoned that if slush samples were made into several very thin sheets, such sheets should dry more rapidly than the thicker sheets usually made for alpha determinations. With this possibility in mind, samples of pulp of known alpha-cellulose content were slurried and made into 1-gram sheets using the Valley sheet mold, and partially dried between blotters on a hot plate. These sheets were then placed under a fan in a constant temperature and humidity room and after about 90 min. were found to be in an air-dry condition. Thus, a saving of over 14 hr. was effected in the preparation of samples from slush pulp. The results of alpha-cellulose determinations made on these sheets were the same as those obtained with pulp conditioned according to the standard procedure.

Attention was next turned to reducing the time required for the accurate determination of the oven-dried weight of the alpha-cellulose pad. In the standard procedure the pad is dried in a 105°C. forced circulation oven for about 4 hr. and after cooling in a desiccator is accurately weighed. TAPPI suggests that the time could be reduced to 2 hr. by giving the alpha-cellulose pad a final wash with alcohol and ether. However, investigation confirmed the findings of O'Brien, Reitz, and Bloom (*2*) that, although the use of many organic solvents accelerates the drying of the alpha pad, their use may result in incorrect values. It was then thought that the weight of the alpha-cellulose pad might be obtained more rapidly by a volumetric method for the determination of alpha-cellulose, which would make the actual drying and weighing of the alpha pad unnecessary. However, it was

Fig. 1. Thermal balance for weighing 500-mg. oven-dry sample

found that the time involved in the volumetric analysis of the alpha-cellulose pad was almost as long as the drying and weighing time required by the gravimetric method.

Another procedure which would make the actual weighing of the alpha-cellulose pad unnecessary is the volumetric determination of beta plus gamma-cellulose and the calculation of the per cent alpha-cellulose by difference. It was found that a volumetric determination of beta plus gamma-cellulose could be accomplished in less than 1 hr. By substituting this method for the gravimetric method requiring the drying and weighing of the alpha pad, a saving in time of about $3^1/_2$ hr. was realized. Thus an alpha-cellulose determination on a sample of slush pulp could be completed in about $4^1/_2$ hr., but this method was still too time-consuming to be of value as a pulp quality control method.

At this point, it was reasoned that if a smaller sample were used, the resulting alpha-cellulose pad would dry more rapidly. The main disadvantage to using a small sample is that nonuniformity of moisture distribution would make the exact determination of the oven-dry weight of a small portion of air-dry pulp extremely difficult. It was decided to eliminate this possible source of error by using oven-dried pulp. Thin sheets of pulp were dried quickly in a forced draft oven at 105°C. and weighed without cooling on an analytical balance. Due to the hygroscopic nature of dried pulp the weighing had to be made within a few seconds after removing the sample from the oven and the weight confirmed by reweighing the sample after a further short drying period. This technique made the exact and rapid weighing of a small sample feasible.

An investigation was then made to determine the size of a small sample most suitable for gravimetric determination. The time required to dry samples of various weights in a 105°C. forced draft oven was noted and the convenience of handling observed. On the basis of this information a sample weight of 0.500 gram was chosen. Alpha-cellulose determinations were then made using oven-dried samples weighing 0.500 gram, but otherwise following the standard procedure as closely as possible. The volumes of 17.5% NaOH solution, dilution water, and wash water were reduced for the smaller sample now being used. The weighing of the alpha-cellulose pad was accomplished without cooling using an analytical balance. Results of determinations performed in this manner agreed closely with those obtained by the standard procedure.

Difficulty was experienced, however, in weighing the sample to 500 mg. prior to analysis, so the possibility of using a thermal balance to expedite this operation was investigated. Since no commercially built thermal balance was available for drying and weighing a 500-mg. sample with sufficient accuracy, it was necessary to design and build one. A model which filled the requirements was constructed from a modified ream scale mounted on a small 105°C. oven so that a sample

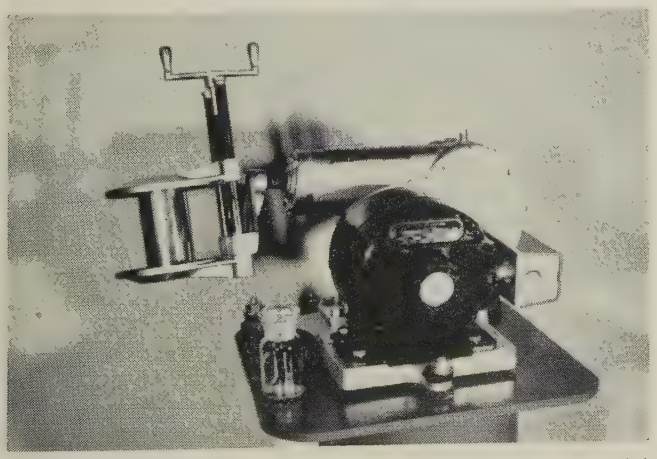

Fig. 2. Shaking device for agitating pulp with 17.5% NaOH slurry

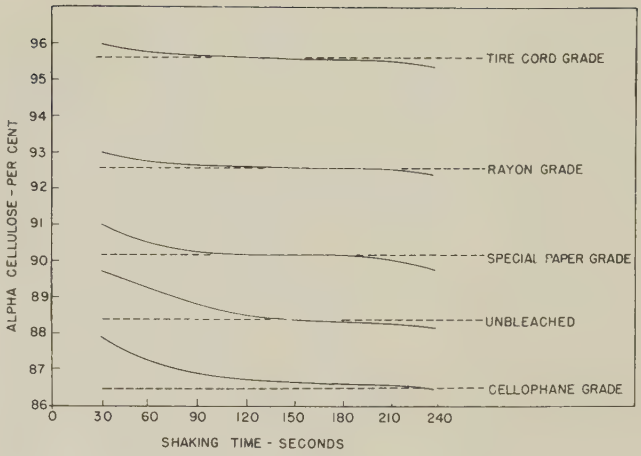

Fig. 3. The effect of shaking time on the observed alpha-cellulose value

could be suspended in the oven on a wire connected to the activating arm of the ream scale as illustrated in Fig. 1. The balance was calibrated by suspending a 500-mg. weight on the wire and marking the point on the scale. The sensitivity of this device was checked by adding small known weights to the 500-mg. check weight. The balance did not at first respond to these small changes in weight because of friction in the ream scale bearing, but this difficulty was overcome by replacing the bearing with one obtained from an alarm clock mechanism. It was then found that samples could be readily weighed to within 0.5 mg. of the desired 500 mg.

The following method was evolved for weighing a sample of pulp with this equipment. The thin prepared sheet of pulp is placed in a 105°C. forced circulation oven for a few minutes to dry it and then about 600 mg. of the pulp are transferred to the thermal balance for the final adjustment to 500 mg. This final adjustment is easily made by tearing off or adding small portions of the sample until the desired scale reading is attained. Because of the hygroscopic nature of the dry sample, care should be taken not to leave the oven door open longer than necessary when making these final weight adjustments.

An examination of the findings at this stage of the investigation revealed that an alpha-cellulose determination may be made in about 80 min. with the following operations:

1. Form the sample into a thin sheet and weigh exactly 500 mg. using the thermal balance (15 min.).
2. Macerate and mercerize this weighed portion with 17.5% NaOH at 20°C. (45 min.).
3. After dilution, wash, dry, and weigh the alpha-cellulose pad (20 min.).

The operation of maceration and mercerization did not merit immediate concern in the preliminary investigations due to the fact that it accounted for only a small portion of the total time required to complete the determination. In the 80-min. procedure, however, maceration and mercerization take up more than 50% of the analysis time. It was felt therefore that efforts to reduce the time required to perform this operation would be warranted.

The purpose of maceration and mercerization is to expose the entire sample to 17.5% NaOH solution so that the soluble portion (beta plus gamma) can be dissolved and then separated from the alpha-cellulose portion by filtration. Experiments were undertaken to determine whether the effect of the 45 min. manual maceration and mercerization period could be duplicated by a comparatively short, high-speed shaking operation. Several mixing devices were investigated for this purpose, and the shaker illustrated in Fig. 2 was selected because it provides extremely vigorous agitation. Oven-dried samples weighing 0.500 gram were shaken in this apparatus with 15 ml. of 17.5% NaOH for about $1^1/_2$ min., and the residual cellulose washed, dried, and weighed. The results ob-

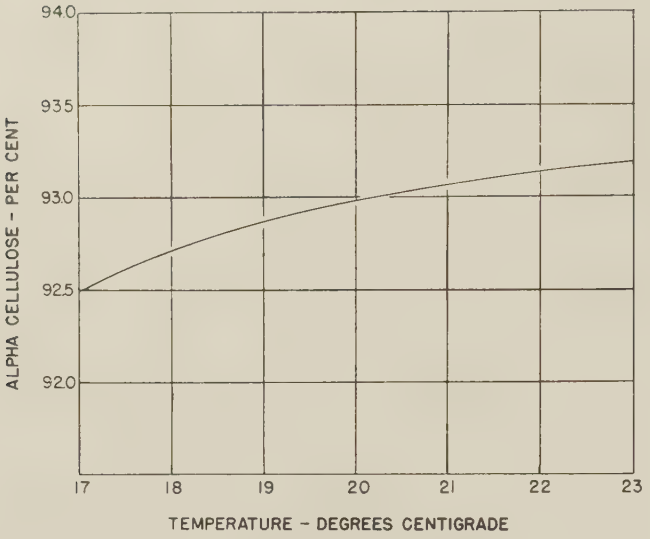

Fig. 4. The effect of temperature on the observed alpha-cellulose value

tained were very close to those obtained by the standard procedure, indicating that this short violent shaking period was duplicating the effect of the standard maceration and mercerization operation.

At this stage little was known about the effect of shaking time on the result of the analysis, or whether all types of pulp would respond in a similar manner. To investigate these points several pulps were selected and each analyzed by the rapid method described using different shaking times varying by 30 sec. over the range 0.5 to 4 min. The alpha-cellulose value for each determination was plotted against the shaking time as shown in Fig. 3. The shaking curves were all similar in shape and flat in the center portion. This flat portion was found to correspond closely to the value for each pulp as determined by the standard method (indicated by broken line on Fig. 3). It was concluded, therefore, that a shaking time of 2 to 3 min. would be suitable for most types of pulp.

The effect of variations in temperature was also investigated. In all previous experiments the 17.5% NaOH solution, water, and equipment were maintained at 20 ± 0.2°C. as specified in the standard procedure. Several analyses were now made in which the chemicals and equipment were conditioned at various temperatures ranging from 17 to 23°C. The results (Fig. 4) indicate that while it may not be necessary to control the temperature as closely as specified for the standard procedure, a change of 1° or more will significantly affect the result.

The rapid method now made possible a complete alpha-cellulose determination of slush or dried pulp in about 40 to 45 min. It was still necessary to establish that it would yield correct values for various types of pulp in process. Samples were taken from mill production and analyzed in duplicate by both the rapid and the standard procedures. Similar comparisons were made on pulps produced from both hard and soft woods by ammonium, calcium, and magnesium bisulphite pulping and by the kraft process. The results of the two methods (Fig. 5) agreed within 0.2, the limit specified for duplicate checks by the standard method.

As a final step the rapid procedure was tried as a control method during a period of production of alpha pulp. It was used to show the alpha-cellulose content of the pulp entering and leaving the caustic extraction stage. Analyses were made about once an hour without difficulty and the results were reported within 1 hr. of receipt of the sample. The values were later verified by the standard procedure. Since this initial trial the rapid method has been used with success during many periods of alpha pulp production. It is relied upon by the operating personnel to provide information as to the alpha-cellulose level whereby the mill operation is more accurately controlled. Furthermore, the rapid method can be performed by one person on a continuous basis. If the samples are provided in the form of partially dried, 1-gram sheets as many as 25 separate determinations can be made in one 8-hr. period.

METHOD IN DETAIL

Procedure

Disperse a 1-gram sample of pulp in water with a Waring Blendor and form the pulp into a handsheet using a sheet mold equipped with a 150-mesh wire. Samples of slush pulp that contain process chemicals should be dispersed with the Waring Blendor and then washed several times in the sheet mold. Washing the pulp results in the loss of some of the smallest fibers known as fines so that excessive washing must be avoided.

Remove the sheet from the sheet mold using two clean blotters. Place the handsheet between the two blotters and heat for about 5 sec. on an electric handsheet hot plate. The sheet should still be steaming when it is removed from the hot plate and should be wet over its entire surface. Remove the sheet from between the blotters and dry it in a 105°C. oven for 3 min. It should not remain at 105°C. for more than 20 min.

Weigh a 0.500 gram sample of the pulp in a 105°C. oven equipped with a balance accurate to 0.5 mg. (Fig. 1) place the weighed pulp in a 60-ml. glass stoppered, wide-mouth bottle which has been brought to 20°C. and add 15 ml. of 17.5% NaOH at 20°C. Stopper the bottle and shake for 150 sec. using a high-speed shaker* (Fig. 2). Add 15 ml. of distilled water at 20°C. to the pulp slurry, mix thoroughly for 5 sec., and pour into a 40-mm. fritted glass funnel (Ace, porosity D.)† Apply suction to remove all of the excess sodium hydroxide from the pulp within 20 sec. and then wash with 750 ml. of distilled water at 20°C. in 100-ml. portions, using the first portions to rinse the bottle and stopper. Increase the suction slightly during the washing.

* Laboratory Model Shaker No. 34, manufactured by Red Devil Tools, Inc., Irvington, N. J.

† The type and porosity of the filter used are important. Ace porosity D with 40-mm. disk, type 8590 is recommended.

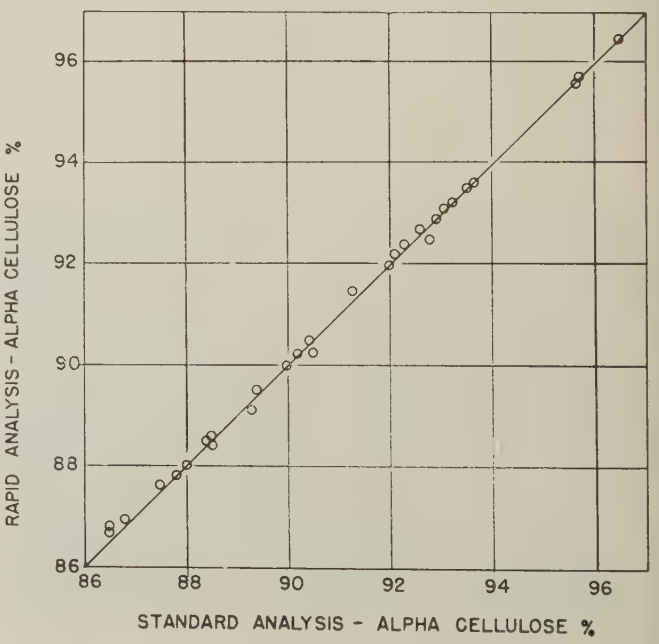

Fig. 5. Comparison of values obtained by rapid and standard procedures

The nature of the pulp pad which is formed on the filter is very important. The pad should cover the entire area of the filter and should be of uniform thickness. To obtain good formation of the pad it is essential that the filter be clean. Filters should be cleaned by back washing with concentrated sulphuric acid or hot dichromate cleaning solution after every third or fourth use.

Carefully remove the pad from the filter and place in a 105°C. forced draft oven and weigh when dry on an analytical balance, or weigh directly when dry in a 105°C. oven equipped with a balance accurate to 0.5 mg. It is absolutely essential that the entire pad is recovered from the filter since the loss of 1 mg. of pulp would reduce the alpha-cellulose value numerically by 0.2%. The per cent alpha-cellulose is calculated from the oven-dried weights of the sample and the alpha-cellulose pad.

If the drying is not being carried out in an oven equipped with a sensitive balance, dry the pad in a 105°C. forced draft oven for 20 min. Weigh on an analytical balance and return to the oven for 5 min. Weigh again to check the first figure obtained and if necessary make subsequent weighings. Repeat the treatment until constant weight is attained.

CONCLUSION

A practical rapid method for the determination of alpha-cellulose in pulp has been developed. This method is suitable for the analysis of various dissolving and paper grades of pulp produced from either hard or softwood by common pulping processes. The rapid method can be used for both slush and dried pulp. The saving in time as compared with the standard method is 21 hr. for slush pulp and 5 hr. for dried pulp.

The method has been used consistently in mill operation for about 2 years to determine the alpha level at various stages in the process. It is of service to the operator because any interruption or failure of the process used to raise the alpha-cellulose level is reflected within an hour in the result of the rapid alpha-cellulose determination. Such immediate knowledge of the alpha-cellulose level permits much closer control of the extraction process and results in a more uniform product.

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A Shibley Award paper presented at a meeting of the Pacific Section of the Technical Association of the Pulp and Paper Industry, Everett, Wash., March 4, 1955.

Paper Handling at the Trimmers

JOHN V. GOULD

In recent years Simpson Paper Co. (formerly Everett Pulp & Paper Co.) has done a great deal to modernize its pulp mill and its paper machines, but little has been done to modernize its finishing and converting departments. Until very recently, it is believed that this was the case with most pulp and paper mills. For example, great strides have been made toward automation in continuous bleach plants, with control instruments that automatically bring the digesters up to proper temperature and pressure, with consistency controllers that automatically open and close valves, and so forth.

But in the finishing rooms, many mills are still moving paper around with hand trucks, a load at a time. Between each operation it is loaded onto skids, pallets, or dollies, then unloaded by hand. Paper is heavy, and this is back-breaking work. There is no continuous flow, and the various machines, such as the trimmers, are often standing idle waiting for the next load.

John V. Gould, Engineer, Simpson Paper Co., Everett, Wash.

At the Simpson Paper Co. on a given shift there are approximately 16 employees in the pulp mill, 28 in the paper mill, and 160 in the converting and finishing departments. The number of employees required to inspect, count, and handle paper going to the trimmers and to package the paper going away from the trimmers is considered excessive and has been a serious problem for years. Perhaps our converting departments are larger proportionately than the average, but these figures will give some idea of why the management decided it was important to tackle this problem.

The paper which is manufactured at this company and consists of book, mimeograph, bond, etc., is handled in a tremendous variety of sizes and grades. It is first inspected and check-counted. The inspectors have to work at a level that varies from about 4 ft. off the floor down to a few inches. This makes for very uncomfortable working conditions. After the paper has been inspected and counted, a hand truck moves it to a loading table where the paper is lifted off in arm loads and piled onto the table until a "cut" is built up. A cut usually consists of three reams, this being about the right amount for the trimmer to handle. This is particularly strenuous labor near the bottom of the load where the paper has to be raised 2 or 3 ft. The cut then has to be pushed onto the trimmer. On an ordinary table this is hard work as the cuts may weigh up to 500 lb. The paper is then trimmed and cut to specified sizes and pushed away onto a long table where it is packaged in a variety of types of cartons. Here again it is slow hard work pushing heavy paper along this table. Some of these cartons are wire-strapped with a hand-strapping machine, and others are sent to the carton press where the air is squeezed out of the package, and it is taped on a rotating table.

Some of the paper is not packaged, but is loaded directly off the trimmer onto skids. A slide board is placed against the front of the trimmer, and the trimmerman plus a helper, slide the paper onto the skid. This seems to work fairly well, except that the trimmerman is only spending about half of his time cutting paper, which, of course, cuts the potential production of a given trimmer in half. Also, the helper is standing idle while the trimmerman is cutting, although it is true that he does pick up the trimmings and throw them in a broke cart.

It was fairly obvious that some degree of mechanization was needed here. The first step was to make a study of the equipment layouts at three other paper companies which have problems similar to our own and which have recently modernized their paper handling methods.

Various members of the company visitied these mills to obtain first-hand information on the shortcomings as well as the advantages of their installations. One of these will be described as being fairly representative of the three mills. The skid loads of paper first go to a series of hoists. A girl at each hoist inspects the paper and counts it when necessary, the hoist keeping the load at a comfortable working level. She then slides off half a ream or so at a time onto an air jet table until a "cut" is built up. This saves the strenuous labor of picking up arm loads of paper and piling them onto a table. This arrangement avoids the moving, storing and rehauling with lift trucks between the inspectors and the trimmer, and also saves the full time labor of one man loading cuts of paper onto a table and pushing them onto the trimmer.

Air jet tables have proved to be tremendous labor savers. A large stack of paper weighing several hundred pounds can be moved as much as 12 or 15 ft. with a very light push. These tables have ball-check air valves mounted flush on their surface. The weight of the paper on them allows compressed air to escape making an air film under the paper. It is this air film that allows the paper to be moved so effortlessly. When the paper is pushed away, the air valves close by a spring action preventing waste of air.

One particular air table on which the cuts are built up is on

wheels (called a shuttle table) so that the edge of the table can be placed flush against the skid-load of paper. When the cut is ready, the table is pushed rapidly against the edge of a slat conveyor. The momentum of the paper carries it onto the conveyor very easily. This conveyor has highly polished maple slats moving about 35 f.p.m. The paper runs off the end of this conveyor onto another shuttle table which is then rolled in front of the trimer, so that the operator can easily push the paper into cutting position. After the paper is trimmed the operator pushes it to his right onto another air table.

At this point, three minor shortcomings of this arrangement should be mentioned. First, a piece of bent cardboard has to be placed under the leading edge of each cut in order to allow the paper to pass from the head end of the conveyor onto the shuttle table without the bottom sheets getting caught in the gap. Second, the trimmerman has to take the time to roll the shuttle table in front of the trimmer, push the paper off of it, and then roll it back again. This cuts down his actual trimming time noticeably. Third, in pushing the paper away from the trimmer to his right, he must use his left hand. Pushing the other way would, therefore, give the slight advantage of using the right hand for this operation.

From this air table the paper goes to one of three packaging tables where it is put into a variety of types of cartons. The cartons are stored in racks overhead. The packaged paper is then pushed onto a gravity roller conveyor where it is sent to a carton press and taped. The packages are then loaded onto skids and sent to the shipping department for weighing labeling, etc.

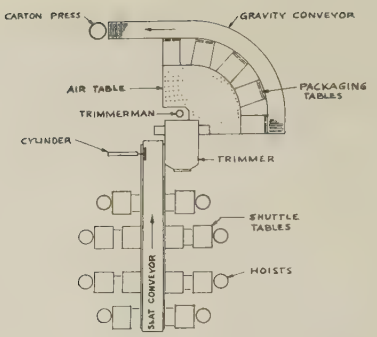
This arrangement apparently has worked out very well. Production at this mill was increased approximately 50% as a result of this installation. The two other companies that were studied also reported similar increases with the output of a trimmer ranging from 36,000 to 55,000 lb. of paper per 8-hr. day. Until recently Simpson Paper Co. has been averaging only about 20,000 lb. per 8-hr. day.

After this study was made of the three paper companies, the next step was to do some experimenting with air jet tables. A simple, boxlike, air-tight table with a masonite top, 2 by 4 wood sides, and a plywood bottom was constructed. This was made air tight, and an air pressure of 1 p.s.i. was supplied by a small blower. One small blower (costing about $200) is capable of supplying eight or ten 4 by 6-ft. tables, and the tables themselves can be built very inexpensively. The mill compressed air supply was first tried, but it was decided to switch to blowers because of an objectionable odor in the compressed air which was impossible to overcome completely. Incidentally, everything from special oils in the compresser to blowing out the lines, oil traps, and even perfumelike deodorants were tried. Also, the cost of piping the compressed air, including reducing valves, safety valves, traps, and gages, virtually offset the cost of a blower. The first table we built leaked slightly, but this was overcome in subsequent tables by using top grade, dressed lumber for the sides. One air table was then set up for feeding paper to a trimmer and one for taking it away. This alone increased the output approximately 3000 lb. per shift.

The next step was to make a drawing of the building area that was available and make cardboard cut-outs of the equipment involved. Sketches were also made showing the layouts at the three mills studied and half a dozen sketches of our own ideas. The motions of the trimmer operators while cutting paper were carefully observed.

The final plan (which is now being built) resembles the one that has already been discussed. Actually there are a number of important differences which we believe are definite improvements.

First, there are eight shuttle tables instead of six, which makes it possible to put extra girls on the line in case they are slowed down by a run of poor quality paper. Also, four storage tables have been placed between the shuttle tables and



Simpson's new paper handling arrangement

a slat conveyor to take up some of the slack in case the girls get ahead of the trimmerman. These two features are intended to make sure that the trimmer is kept busy continuously. The extra tables are placed in two center locations so that the center inspection hoists are out where a lift truck can easily load them from two directions. The tops of the hoists are round making it possible to load them at any angle and then rotate the load to the desired position. This saves the lift truck a considerable amount of jockeying around. It also means that a wide aisle does not have to be maintained for the truck to turn in.

One of the salient features of the scheme is a cylinder pusher which feeds the *back* of the trimmers. When the cut arrives at the head end of the conveyor, it trips a limit switch which stops the drive motor of the conveyor and also actuates the cylinder which pushes the paper onto the trimmer. A limit switch prevents the cylinder from operating unless the back gage on the trimmer is in the back position to receive the paper. The minute the trimmerman is through making one cut, he pushes a button to run his gage to the back position. Then, while he is pushing away his first cut, the next one is automatically loaded onto the trimmer. There should be virtually no time lost between cuts.

Another advantage of this arrangement is that the piece of cardboard under the leading edge of the cut is not needed when the paper is pushed sideways off the slat conveyor. (Admittedly, the cardboard may be needed for larger sheets where they cross the center groove of the trimmer) also an extra shuttle table is eliminated, allowing the operator to concentrate on trimming paper; and it is to be noted that the paper is pushed away from the trimmer with his right hand.

One of the most obvious differences between the present arrangement and the one which was studied is the fan-shaped take-away table. The advantage of the present design is that the operator can feed paper directly to the different packaging tables in rotation. When paper is not being packaged but is being loaded directly onto skids, the long straight edge of the take-away table is used to slide the paper off. This means that the trimmerman does not have to help with the skid loading. He can push away one cut and start on the next without having to perform any intermediate tasks.

A ball-top wire-strapping unit has also been added to speed up the banding of packages when it is required. This whole end of the operation is entirely flexible. The gravity conveyor is broken into 6-ft. sections which can be easily moved around to suit changing conditions.

In concluding, it is believed that a 50% increase in the output per trimmer can conservatively be anticipated and roughly a 25% increase in the output per man-hour. But if all the innovations work out as they are expected to do, these percentages may be increased significantly. Even with the lower figures, this comparatively inexpensive installation should pay for itself quickly and result in substantial savings for the company.

A Shibley Award Paper presented at a meeting of the Pacific Section of the Technical Association of the Pulp and Paper Industry, Everett, Wash., March 4, 1955.

A Simple Test to Aid in the Control of Brown Stock Washing

JOHN B. GRIFFITH

Brown stock washing, considered as an operation, is the separation of the solid product of kraft cooking, pulp, from the liquid product, black liquor. It is desirable that the separation be as complete as possible, that is, the pulp washed free of residual black liquor. Likewise it is desirable that recovered black liquor be as concentrated as possible. The operation may be viewed as both the last stage in pulp preparation and the first stage in chemical recovery, and it is characteristic of this operation that pulp cleanliness and chemical recovery are at odds. To put excessive emphasis on one results in loss of efficiency or poor operation of the other.

In the control of brown stock washing there are two basic problems. The first is to discover the proper operating level, and the second is to maintain the operation at this level. The problem of operating level is essentially economic, and the individual mill must decide the proper balance of the costs involved, which include primarily those of soda loss at the washers and evaporator steam resulting from the corresponding black liquor dilution. Other costs may enter in, for example, that of chlorine consumed by residual black liquor in the pulp in bleaching or that of production lost by foaming as the stock is screened. There is a limit, of course, to the amount of residual black liquor that can be tolerated in the pulp without seriously harming subsequent processes and pulp and paper quality. The economic balance is concerned with amounts that are below this limit.

To make a realistic balance washer performance data which correlate soda loss and evaporator steam costs for the particular washing situation are required.

A generally accepted method for acquiring these data is the "dilution-factor" method described by Lientz (*1*) and elaborated by Waters and Bergstrom (*2*). A fairly simple testing procedure allows a performance curve to be drawn of soda loss as a function of dilution factor, which is defined as pounds of water entering the system as dilution per air-dry pound of pulp. Waters and Bergstrom (*2*) give a typical curve, Fig. 1, for a two-drum, three-stage washer handling Douglas-fir and hemlock. This roughly hyperbolic curve clearly demonstrates the washer's capabilities for a particular type of pulp and rate of washing. The technical information that this curve gives can be easily converted to the economic by translating soda loss to salt cake make-up cost and dilution factor to evaporator steam cost.

The testing procedure is based on a simple water balance over the washer, the dilution factor being the ratio of the difference between the fresh water added at the last stage shower and the water leaving the system in the pulp to the pulp production rate, all terms expressed in pounds. The rate of flow of fresh water is varied in steps over a wide range; and at each setting after equilibrium has been reasonably established, the pulp coming off the washer is sampled for consistency and soda loss determinations. There is a difficulty with this method which is mentioned here because it will be pertinent later in this paper. This is because the dilution factor is calculated from a difference, and the magnitude of this difference is only about 20% of that of its terms. Thus, an error of 5% in measuring shower water flow, production rate, or consistency would cause a 25% error in the dilution factor. The severity of this type of error increases with decreasing dilution factors. At Camas, we have been unable to get reliable determinations in this range.

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THE PROBLEM OF IMMEDIATE CONTROL

The variables which affect washer operation can be classified into two groups: those which exist and must be controlled prior to the washing operation and those which occur in the operation. Among the former are production rate, wood species, the softness or hardness of the pulp, its foaming tendency, the relative amount of shives in the pulp, digester and blow tank dilution, blow tank consistency, and shower water temperature. Fluctuations in these produce variations at the washers, and an effort must be made to keep them reasonably constant.

Variables which the washer operator controls are vat consistency, drum speed, rates of flow of shower water and filtrate, and the distribution on the drum of these showers. Both low vat consistency and low drum speed make for good washing efficiency, the former by contributing to the forming of a uniform pulp sheet, and the latter by permitting more time for drainage through the sheet and out of the drum. Since both decrease production rate, the operator must sacrifice some of the benefits of both in order to strike a balance and keep up the production rate he has to meet. Drum speed cannot exceed that which allows sufficient time for drainage from the drum interior. At high production rates this may cause difficulty. The rate of flow of shower water is the most important variable because it most directly determines pulp cleanliness and black liquor dilution.

METHODS OF CONTROL

Since both concentrated black liquor and clean pulp are to be attained, methods of washer control take both into account. The control of the concentration of black liquor leaving the washer is universally achieved through its specific gravity–per cent solids relationship, the Baumé of the liquor being the standard measure. Control of the residual black liquor in the pulp is brought about either by visual inspection of liquid squeezed from the pulp or by a method based on the conductivity-concentration relationship of dilute black liquor solutions.

The conductivity of the last stage filtrate is sometimes used as a measure of pulp cleanliness where the system is not closed (*3*). West, Collins, and Bergstrom (*4*) describe a test which measures the conductivity of the liquid squeezed from the pulp and relates this to soda loss, and state the test capable of being run by unskilled personnel and accurate for operational control.

At Camas, hourly black liquor Baumé measurements are made at each washer by the operator. Until recently, however, there was no quantitative control test made on the washed pulp. Visual inspection of the pulp served as a check on pulp cleanliness.

THE PROBLEM AT CAMAS

At present the washing problem at the Camas mill is primarily one of immediate control. There are two causes of this situation. First, the mill is a specialty mill and there are, consequently, periodic changes in pulp species scheduled over individual washers, which to the washing operation are a complication. Second, and primarily, the capacity of the evaporators is limited. This naturally puts rigid limits on the amount of dilution permissible and on the leeway the process has to meet its requirements. No definite washer setting can be made by the operator for each situation he must handle. Much of the success of the operation depends on the skill and experience of the operator in knowing how to adapt his equipment to changes when they occur and to make use of whatever control guides he has.

THE PULP CLEANLINESS TEST

Last Summer, after a pulp production increase of about 8%, it became necessary to furnish the washer operators with a

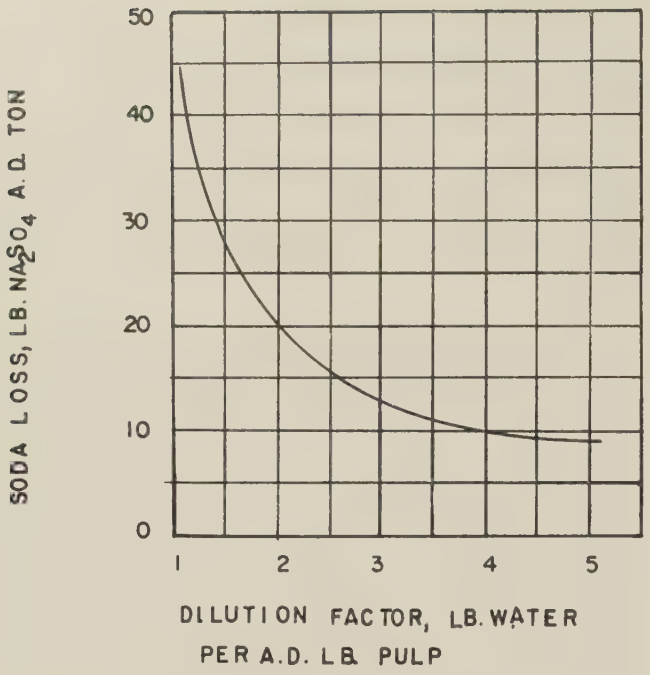

Fig. 1. Typical dilution curve

definite guide for the residual black liquor content of the washed pulp. Apparently the necessity of keeping the liquor to the evaporators sufficiently concentrated diverted too much attention from the condition of the washed pulp. A simple test, essentially the same as that described by West, *et al.* (*4*), was put into use.

The procedure is simple. The operator samples the pulp from the washer, squeezes liquid from it, and after a standard dilution, measures the resistance of the solution. The equipment is likewise simple. An industrial instruments conductivity bridge model RC with a CEL-4 conductivity cell is used for measurement. A piece of old-fashioned kitchen equipment, a potato ricer, is the press to squeeze out the sample. Thirty milliliters of liquid, squeezed from the pulp sample, are diluted to 110 ml. and the solution resistance, in ohms, measured and recorded.

Tests are run hourly on all washers by the operators. Although the conductivity of dilute black liquor solutions is almost directly proportional to its concentration, and therefore, strictly speaking, would be a more logical figure to use, the instrument reads resistance, and that figure has been used for the sake of simplicity.

No effort is made to control temperature or to compensate for variations of temperature or consistency, both of which remain reasonably constant. Temperature remains fairly well in the range of 75 to 80°F. The cell constant since late December when the electrodes were replatinized is approximately 2.0, and periodic checks of this are made with 0.01 *M* KCl (*5*). Prior to that time it was checked as 2.6.

EVALUATION OF THE TEST

Shortly after this test was put into use, operating personnel concerned with screening and bleaching reported that the pulp seemed cleaner. On the basis of these reports, it was decided to continue the test. Some months later sufficient data were accumulated and a more definite evaluation was made. This was done by making a systematic investigation through mill records pertaining to washing and also to those points in subsequent operations which might be affected by the residual black liquor in the pulp.

It would be expected that if the use of the pulp cleanliness test resulted in cleaner pulp, the data of routine mill soda loss determinations would show it. These data, as monthly averages, are given in the first two columns of Table I. The

Table I. Soda Loss and Chlorine Usage Data Before and After Pulp Cleanliness Test

	Monthly av. soda loss, lb. Na_2SO_4/ton		*Cl_2 used in first stage, %*	*Wiles Bleachability*	*Cl_2 used in hypochlorite stage*
	No. 1 side	*No. 2 side*			
June	35	49	8.13	14.6	2.20
July	53	49	8.01	13.8	2.27
August	63	45	7.81	14.3	2.38
Three-month av.	50.3	47.6	7.98	14.2	2.28
September	44	54	7.18	14.4	2.43
October	39	50	7.01	14.3	2.27
November	32	40	7.03	14.4	2.15
Three-month av.	38.3	48	7.07	14.4	2.28

test was started around September 1, so the data are grouped according to the 3 months prior to and after this date. The kraft mill is split operationally into two "sides" in order to segregate pulp species. Data of both sides are reported. There was a decrease shown at no. 1 side, the 3-month average decreasing from 50.3 to 38.3 lb. per ton. On the other hand, the no. 2 side average remained practically constant. These tests are made once per shift by pulp testing personnel using a method based on a calibrated conductivity cell. A conservative attitude should be held regarding these data because the sampling frequency is only three tests per day, and the washing process has a rather large degree of necessary variation, so that washer conditions often change significantly more frequently than the tests are made.

The remaining columns in Table I list data pertaining to the bleaching of one grade of kraft pulp, which is bleached in three stages to a brightness of 65% G.E. This grade is run the majority of the time at a production rate of 150 to 200 air-dry tons per day. It can be seen that the first-stage chlorine demand decreased noticeably in the 3 months after the pulp cleanliness test was begun. The probability that this was due to cleaner pulp being furnished to the bleach plant is indicated by the average pulp bleachability remaining almost constant, as also did the hypochlorite usage. The decrease in chlorine used was entirely in the chlorination stage.

Examination of the results of hourly residual chlorine tests made after this stage give further evidence for cleaner pulp. Figures 2 and 3 represent data for the respective periods 1 month prior to and 1 month after the introduction of the pulp cleanliness test. They are histograms showing frequency distribution of residual chlorine content. It is attempted to control to a residual of a trace to 2.0 lb. Cl_2 per ton. In comparing the histograms it is noted that after the pulp cleanliness test was begun there was a marked decrease in number of tests in the range 0 to 0.25 lb. per ton. (This range is at the extreme left of the histograms.) Practically all of the

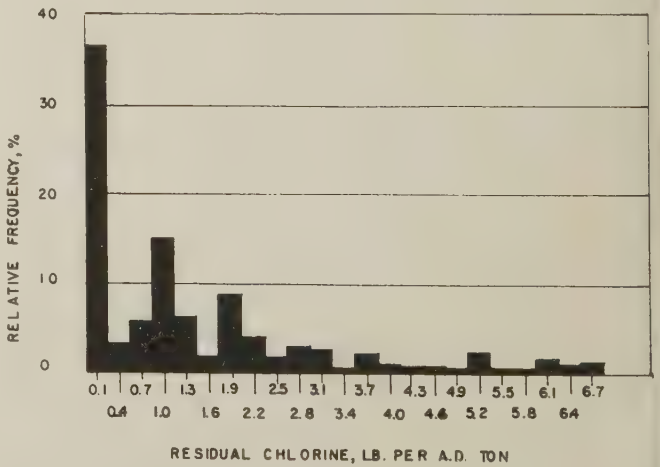

Fig. 2. Distribution of first-stage residual chlorine tests before pulp cleanliness test

tests which fall in this range show no or only a trace of chlorine. During August 36.7% of the tests fell in this range, while during September this decreased to 23%. There were 400 individual tests during each period so this difference is considered significant.

Relatively large amounts of residual black liquor in the stock, especially if coming in periodic surges, would be expected to cause the chlorine to exhaust more frequently in this stage. The organic matter in the residual black liquor consumes appreciable chlorine. The operators must, during normal operation, keep the residual chlorine content down or literally be driven from the bleach plant by chlorine gas. Therefore, a surge of excess residual black liquor would be expected to exhaust the chlorine.

CONTROL AT THE WASHERS

Evidence pointing to improved washer control by reduction in variability is shown in Fig. 4. These histograms represent the frequency distributions of Baumé tests at a 9 by 12-ft., two-drum, three-stage Swenson-Nyman washer, when handling hemlock at 235 tons per day. The upper histogram represents 268 individual tests taken over a 13-day period last August. The lower represents 212 individual tests taken over a 10-day period during January of this year, while the pulp cleanliness test was used. This latter histogram shows a narrower spread, and extremes in operation shown in the former are missing. The high liquor concentrations represented by the right-hand tail in the upper figure would be accompanied by high soda losses. The swings in operation which produce the data shown in this tail are usually of several hours' duration and are the result of intentional operation at the time. The operator's attention being directed periodically to the condition of the pulp by testing it, this type of operation would be expected to decrease in frequency.

CORRELATION WITH DILUTION

While the use of this conductivity test had as its initial purpose only the immediate control at the washers with not much attention being given to the actual meaning of the test results, in going through the data in preparing this paper, it came to light that the data have value in analyzing the performance of the washers and evaluating the economics of their operation. It has provided a means of correlating washer operation with both evaporator steam costs and chlorine costs in the bleach plant.

The evaporator correlation will be discussed first. Table II lists daily averages of black liquor gravity in degrees Baumé and of the pulp cleanliness test in ohms. It will be recalled that both these tests are run hourly. The data are

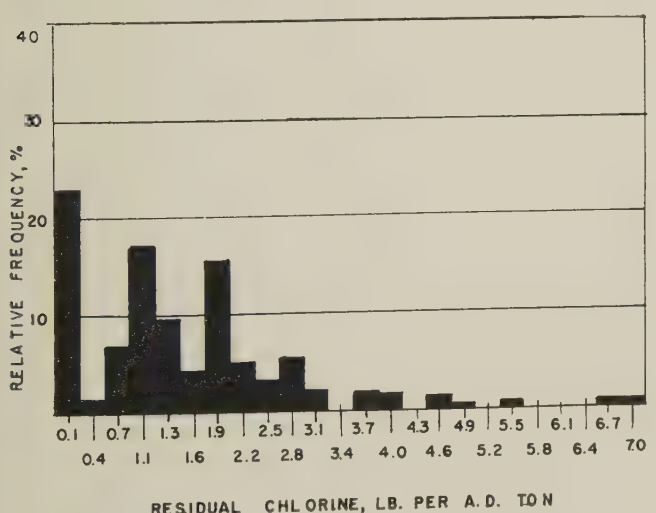

Fig. 3. Distribution of first-stage residual chlorine tests after pulp cleanliness test

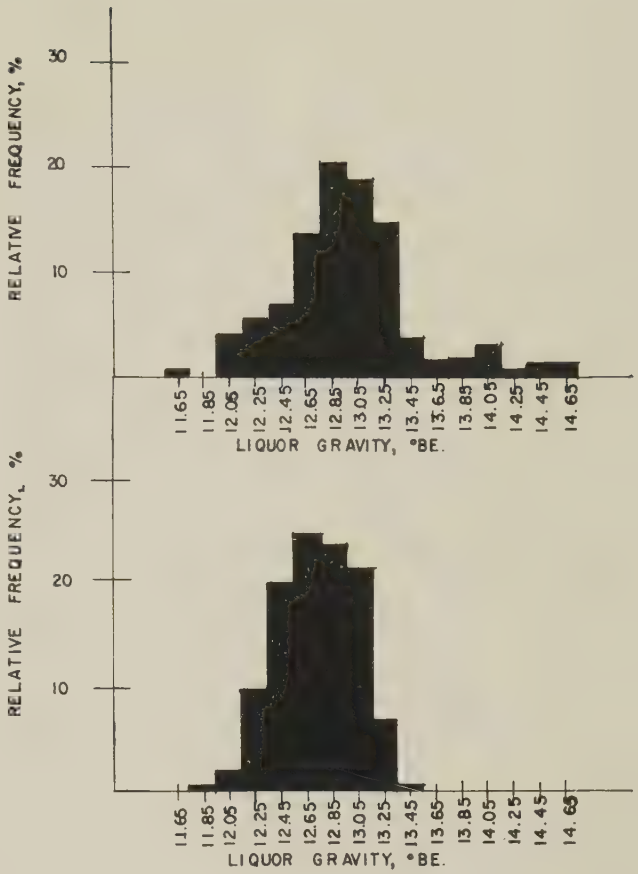

Fig. 4. Comparison of distributions of black liquor Baumé tests before and after pulp cleanliness test

from the previously referred to Swenson-Nyman washer, handling 240 tons of Douglas-fir pulp per day. The data which represent 26 days' operation are plotted in Fig. 5.

The standard methods of linear regression analysis are used

Table II. Daily Averages of Pulp Cleanliness Test and Black Liquor Baumé

Date	X R_{av}, (ohms)	Y Av., liquor density, (° Bé.)	Date	X R_{av}, (ohms)	Y Av. liquor density, ° Bé.
Dec. 28	1955	13.45	Jan. 16	2471	12.98
29	2070	13.52	28	1715	13.00[a]
31	2095	12.89[a]	29	1650	13.62
Jan. 1	2089	12.81[a]	30	1604	13.96
4	2217	13.22	31	1575	13.80
5	2088	13.83	Feb. 1	2125	13.49
6	2172	13.33	2	2450	13.13
7	2875	12.95	3	2058	13.17
8	2500	13.12	4	1800	13.74
9	2318	13.14	5	2044	13.27
10	2430	13.12	6	1874	13.72
11	2629	12.91	7	2024	13.54
12	2282	13.08	9	2841	13.11
13	2144	13.43			
14	2458	13.12			
15	2317	13.31			

$n = 26$

$\Sigma x = 56{,}971$ $\quad \Sigma y = 347.06$ $\quad \Sigma(x - \bar{x})(y - \bar{y}) = -2183.38$

$\Sigma(x - \bar{x})^2 = 2{,}917{,}668$ $\quad \Sigma(y - \bar{y})^2 = 2.1978$

$$r = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma(x - \bar{x})^2 \Sigma(y - \bar{y})^2}} = \frac{-2183.38}{\sqrt{2{,}917{,}668 \times 2.1978}} = 0.864$$

[a] These points represent days of unusual conditions and are not included in calculations.

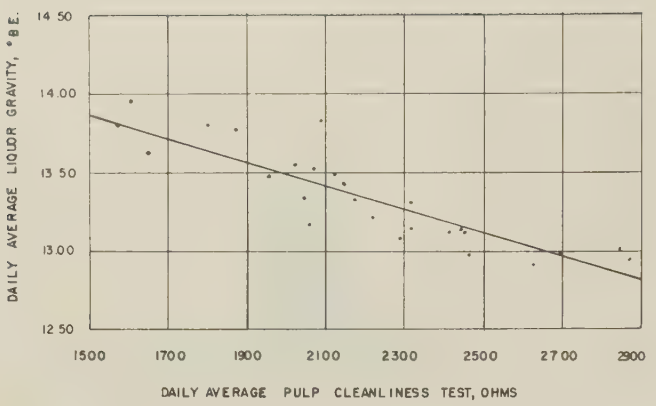

Fig. 5. Correlation of daily averages of black liquor Baumé and pulp cleanliness tests

to draw the regression line, since the appearance of the data strongly suggested a linear correlation. This, then, is the line of best fit, and is calculated as follows:

$$y = \frac{\Sigma y}{n} + \left[\frac{\Sigma(y - \bar{y})(x - \bar{x})}{\Sigma(x - \bar{x})^2}\right]\left[x - \frac{(\Sigma x)}{n}\right]$$

With y = black liquor gravity in degrees Baumé, and x = the average of pulp cleanliness test in ohms, the following equation is derived:

$$y = 14.99 - 0.748 \times 10^{-3}x \qquad (1)$$

This equation is of value because it can easily be changed to an expression relating solids content of the black liquor to soda loss at the washer, and from this, with a little additional operating data from the mill, a curve of dilution factor versus soda loss can be derived. The solids content of black liquor over the range of 15 to 20% is linearly related to its gravity at 60°F. by the following equation:

$$S = 1.42\ (°\text{Bé.}) - 0.80 \qquad (2)$$

where S = per cent solids of black liquor. The conductivity cell used for the pulp cleanliness test has been calibrated using the zinc uranyl acetate method for sodium analyses, and the concentration of sodium expressed as grams per liter of Na_2SO_4 as a function of resistance, in ohms at 75°F., is given the following equation:

$$C_{Na_2SO_4} = \frac{1670}{R} - 0.13$$

Recalling that in the test procedure 30 ml. of the liquid squeezed from the pulp are diluted to 110 ml., the expression for soda loss in pounds per air-dry ton becomes

$$L = C_{Na_2SO_4}\frac{(110)}{30}\frac{(1800)}{1000}\left(\frac{100}{C} - 1\right)$$

where L = soda loss, and C = consistency in per cent. At a washer consistency of 17.0%, $L = 32.2\ (C_{Na_2SO_4})$. By substitution in the cell-calibration equation

$$L = \frac{53{,}800}{R} - 4.2 \qquad (3)$$

and by expressing equations (2) and (3) in appropriate terms and substituting in equation (1) there is obtained an expression of black liquor solids content as a function of soda loss:

$$S = 20.50 - \frac{57.3}{L + 4.2} \qquad (4)$$

With additional data of the pounds of solids per air-dry ton of pulp and the black liquor solids content as blown, a dilution curve can be drawn. At the Camas mill pulping Douglas-fir there are figured 3350 lb. black liquor solids per ton. The solids content as blown has not been checked recently, but is estimated for this illustration as 22.5%, which should be close to the actual figure. On these bases the dilution factor can be calculated as follows:

$$\text{Dilution factor} = \frac{3350}{2000} \times \left(\frac{100}{S} - \frac{100}{22.5}\right) \text{ lb. water per air-dry lb. pulp}$$

Using this and equation (4), the curve shown in Fig. 6 is drawn.

The value of a dilution curve derived by this method should be that it comes from operating data which cover an extended length of time, and it enables a fairly definite curve to be established in the range in which the washer normally operates. In most cases economy dictates low dilution factors, and therefore it establishes the curve in the range where the water-balance method is difficult to apply. In order for the curve to be true, all the data used in its derivation must reliably describe average conditions.

CORRELATION WITH CHLORINE USAGE

It has been possible to correlate the pulp cleanliness test with chlorine usage in the kraft bleach plant and to get an estimate of the magnitude of the effect that residual black liquor has on chlorine consumption. It was found that daily test averages expressed as micromhos, i.e., $10^6/R_{av}$, when paired with first-stage chlorine demand for 65% G.E. kraft for the corresponding days, yielded a linear correlation which was statistically significant. Table III lists the data for 31 days. Pulp cleanliness test data refer to the Swenson-Nyman washer previously described while washing Douglas-fir pulp. The bleached pulp was a 50-50 mixture of Douglas-fir and hemlock. So the correlation gives a measure of the effect on chlorine usage of the residual black liquor in the pulp which makes up 50% of the furnish. Late in December the conductivity cell was replatinized, and the cell constant changed from 2.6 to 2.0. This necessitated correcting the data to a uniform cell constant. The last three columns in Table III show the correction to a cell constant of 2.0.

The data are plotted in Fig. 7. As can be seen, there is a high degree of variability, and first it was necessary to test the data to establish whether or not a correlation probably exists. This was done by regression analysis. Letting x = the corrected values of $10^6/R_{av}$, and y = % Cl_2, the correlation coefficient, r, was calculated as follows:

$$r = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma(x - \bar{x})^2\Sigma(y - \bar{y})^2}} = 0.698$$

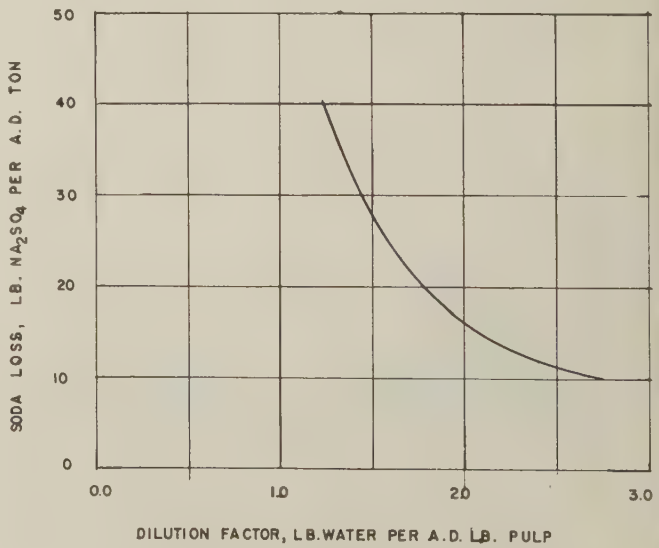

Fig. 6. Derived dilution curve

Table III. Correlation Between Chlorine Usage and Pulp Cleanliness Test

Date	R_{av}, ohms	$\frac{10^6}{R_{av}}$	Cell constant k	$\frac{10^6}{R_{av}} \times \frac{k}{2.0}$ (x)	% Cl_2 (y)
Nov. 22	2717	368	2.6	479	7.71
23	3143	318	2.6	413	7.52
24	2781	360	2.6	467	7.18
25	3542	282	2.6	367	7.36
26	2978	336	2.6	437	7.33
27	3200	312	2.6	406	7.35
28	2500	400	2.6	520	7.46
29	2505	399	2.6	519	7.51
30	2476	403	2.6	525	7.19
Dec. 2	2707	369	2.6	480	8.60
3	2088	478	2.6	622	8.58
4	2402	416	2.6	541	8.69
5	2513	398	2.6	517	8.51
6	3222	310	2.6	403	7.49
Jan. 2	2040	490	2.0	490	7.50
4	2220	451	2.0	451	8.05
5	2090	478	2.0	478	7.62
6	2230	450	2.0	450	7.20
7	2970	317	2.0	317	6.81
8	2590	385	2.0	385	6.80
9	2650	377	2.0	377	7.15
10	2430	412	2.0	412	7.12
11	2630	380	2.0	380	6.53
12	2670	374	2.0	374	7.08
13	2140	465	2.0	465	6.54
14	2460	417	2.0	417	6.95
15	2320	431	2.0	431	6.44
16	2650	378	2.0	378	7.12
28	1750	582	2.0	582	7.59
29	1650	616	2.0	616	7.67
30	1604	623	2.0	623	8.30

$n = 31$

$\Sigma x = 14{,}304$ $\quad \Sigma y = 230.95$ $\quad \Sigma(x - \bar{x})(y - \bar{y}) = 1053$

$\Sigma(x - \bar{x})^2 = 207{,}920$ $\quad \Sigma(y - \bar{y})^2 = 10.977$

With $n - 2 = 29$ degrees of freedom, this value of r is significantly greater than zero at less than the 0.001 level (*6*). In other words, there is less than one chance in a thousand that a value of r this large could be arrived at by chance.

The equation of the line of regression was next calculated by methods previously described and came out to be:

$$\% \text{ Cl}_2 = 5.11 + \frac{5070}{R_{av}} \qquad (5)$$

This relationship obviously is not definitely defined by the extremely variable data, but represents the best estimate from the data available. The equation can be combined with equation (3) to give an expression relating chlorine usage to soda loss:

$$\% \text{ Cl}_2 = 5.41 + 0.0943L \qquad (6)$$

An idea of the magnitude of the influence of residual black liquor on chlorine consumption can be had by noting the difference in chlorine demand for soda loss values of 15 and 30 lb. per ton. At 15 lb. per ton

$$\% \text{ Cl}_2 = 6.83\%$$

and at 30 lb. per ton

$$\% \text{ Cl}_2 = 8.24\%$$

If chlorine costs 3¢ per lb., then an increase of soda loss of 15 lb. per ton is accompanied by an increase in chlorine cost of $0.85 per ton. The relationship given above is of little use for predicting chlorine use at any particular time because of the nature of the data on which it is based. Its value is in figuring chlorine usage over longer periods of time, and hence it furnishes information that can be used in economic investigations.

ECONOMIC BALANCE

Use is made of the foregoing correlations to make an illustrative economic balance of salt cake, evaporator steam and chlorine costs. In order to make necessary calculations, the following operating and cost data are assumed:

Evaporator steam economy	3.75
Black liquor solids content as blown	22.5%
Black liquor solids content after evaporation	55.0%
Amount of total pulp production that is bleached	50.0%
Steam cost	40¢/1000 lb.
Salt cake cost	0.91¢/lb.
Chlorine cost	3.0¢/lb.

Figure 8 shows three cost curves as functions of soda loss..., those of steam, steam plus salt cake, and steam plus salt cake plus chlorine. The steam plus salt cake cost, the usual balance, although nearly constant shows a minimum at a soda loss of 25 lb. However, when chlorine costs are considered, there is no minimum, total cost decreasing constantly with decreasing soda loss. The practical significance is that it would be worth while when evaluating brown stock washing, considering additional washing capacity, or setting operating levels to take into account chlorine costs. A test such as the pulp cleanliness test and the statistical techniques for handling quite variable data are means of obtaining necessary relationships.

EVALUATING DAILY PERFORMANCE

Figure 5 could be made to serve as a daily process control chart if the washer operates under essentially constant conditions from day to day. In many manufacturing processes it has proved advantageous to refer the process to the rules of probability in order to differentiate between normal and abnormal operation. Operation thus classified as abnormal is then investigated in the hope of eliminating its cause and of generally improving the performance of the operation. This is done by calculating and drawing in confidence limits parallel to the regression line. If the 95% confidence limits are chosen, then 95% of all points should lie between these lines. In operation these points would be considered representative of normal operation. Points outside these limits would be considered abnormal, and the conditions investigated. First, the residual variance around the regression line, parallel to the y-axis, is calculated from the following formula (*6*):

$$S_r = \sqrt{1 - r^2}\,\frac{\sqrt{\Sigma(y - \bar{y})^2}}{n - 2}$$

Referring to the data and statistical calculations in Table II

$$S_r = \sqrt{1 - (0.848)^2}\,\frac{\sqrt{2.198}}{24} = 0.158° \text{ Bé.}$$

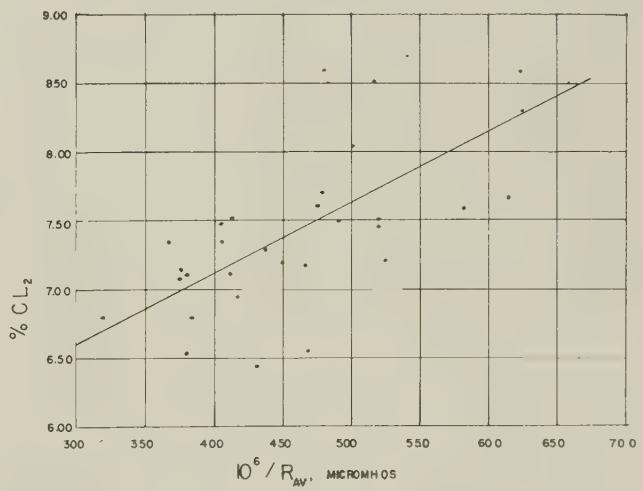

Fig. 7. Correlation between first-stage chlorine demand and daily average of pulp cleanliness test

To convert S_r to 95% confidence limits, it is multiplied by a statistical parameter, t, at its value for $n-2 = 24$ degrees of freedom and at the 95% confidence level (7). From the appropriate tables $t = 2.06$, and $S_r t = (2.06)(0.158) - 0.32°$ Bé. above and below the regression line. These lines become control limits for this particular washer. In Fig. 9 this is shown.

In Table II there are three days' data marked with an asterisk and the corresponding points in Fig. 9 are encircled. These were days when there were unusual conditions prevailing on the washer, and this is plainly shown by reference to the control limits. The point designated by the arrow represents a day of experimental operation on the washer, water paths through the system being changed. It actually amounted to changing the washer from three stages to two, and the corresponding drop in its level of performance is shown by the location of the point. Black liquor concentration decreased significantly from what is normal for the indicated pulp cleanliness.

SUMMARY AND CONCLUSIONS

The control of brown stock washing includes two problems. First, there is the problem of finding the most economic level for the operation as a whole, considering chemical and process costs. Second, there is the problem of immediate control, that is, of maintaining the washing operation within reasonable limits at this predetermined level. This includes control of both black liquor concentration and pulp cleanliness.

The Camas mill of Crown Zellerbach Corp. faced with a problem of the second type has found a simple pulp cleanliness test worth while as a control aid. Based on the conductivity principle, the test is run hourly on all washers by the washer operator. Mill records have indicated that variation at the washers has been reduced. In addition, a sizable reduction in first-stage chlorine consumption in the bleach plant, occurring simultaneously with the introduction of this test, was probably due to improved washer control.

The test also furnishes data which can be used to investigate the economics of particular washing systems. It was possible to correlate these data with both black liquor dilution at the washer and chlorine usage in the bleach plant. This allows economic balances to be made which consider the costs of salt cake make-up, evaporator steam, and chlorine.

Daily averages of test data of the pulp cleanliness test correlate closely with daily averages of liquor Baumé. Advantage can be taken of this by using statistical methods to make

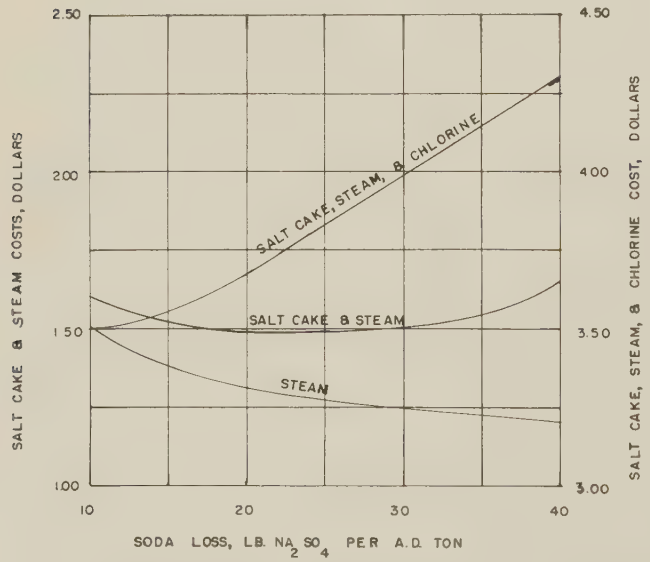

Fig. 8. Costs of salt cake, evaporator steam, and chlorine as functions of soda loss

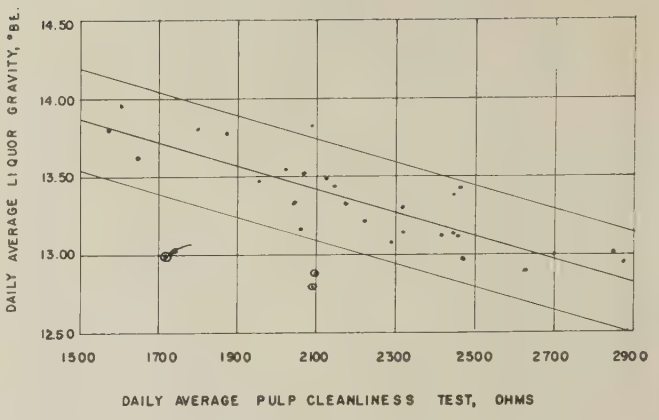

Fig. 9. Washer performance control chart

a type of control chart for evaluating day-to-day performance of a particular washer.

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Unique Structural Treatment in New Filter Plant

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In planning the physical layout of the Everett kraft mill it was necessary, because of the odd shape and limited size of the plant site, to utilize the area available to the best possible advantage. A conventional rapid sand filter plant was selected to supply the mill requirements of 28 m.g.d. of filtered water. It was determined that in order to conserve space, this plant should be housed in three large and two small circular concrete structures, rather than using conventional rectangular construction. This represented a radical departure from accepted practice for there is little or no precedent for this type of construction, in a filter plant of this large size.

The problem then was to design, in concrete, two circular coagulation and settling basins 128 ft. i.d. and 18 ft. high; two circular mixing chambers 28 ft. i.d. and 22 ft. high; one circular structure 128 ft. i.d. and 27 ft. high to house nine rapid sand filter beds, a clear well, a pipe gallery, a pump gallery, and a control deck; and the flumes and other appurtenances necessary to complete the project.

In addition to the fact that there was little or no precedent for a structure of this type for this service, a further complication was added in that the contractor was already on the site at the time the structural design was begun. As a result, it was necessary to design the structure, not from the top down, as is customary, but from the ground up in the

same order as it was to be built. This fact alone dictated that the design would have to be adequate to meet all contingencies the first time around. When a structure is built concurrently with the design, a correction or modification usually involves the demolition of part of the structure already built, not the mere revision of a drawing.

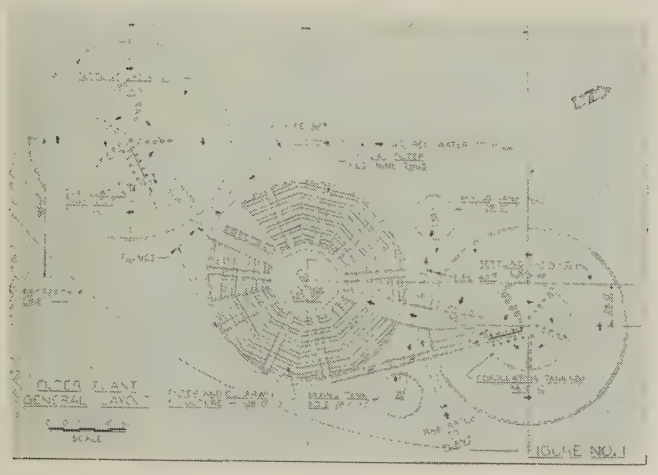

Fig. 1. General layout of filter plant

The physical layout of this filter plant and the control system for it were designed for the Weyerhaeuser Timber Co. by the Northwest Filter Co. of Seattle, a company founded by the late Kenneth "Cap" Shibley, for whom the Shibley Award was named. This layout is shown on Fig. 1.

With this general arrangement available, it was possible to set elevations so that leveling and the necessary excavations could proceed. This provided a few days grace during which time it was possible to arrive at structural systems to use and to prepare piling plans. Then with the piling plans at hand, the contractor was able to proceed with the driving of the piles which in turn gave the author the opportunity to begin the design of the structures. This procedure was typical and from the beginning until the completion of the plant, it was a matter of the contractor standing at the designer's elbow ready to rush each new drawing to the men in the field as soon as it was completed.

In spite of the difficulties outlined above, the five structures were completed on schedule and water was first turned into the plant on July 22, 1953. It has been in continuous service since that time. The structural design has proved to be adequate in all respects.

The following is a general discussion of the major problems encountered in the structural design of this filter plant and the solutions to these problems as they were finally resolved.

FOUNDATIONS

An investigation of the foundation conditions at the building site revealed that a blanket of decomposing sawdust about 18 in. thick overlayed the entire area just below grade. Under the sawdust was a 7-ft. layer of course sand followed by a 9-ft. lens of highly compressible clay. Below the clay was a strata of course sand and silt of undetermined depth.

It was decided, because of these unfavorable conditions, to support the entire plant on piling.

MIXING TANKS

The two small cylindrical mixing tanks are not unusual either in size or design and will be touched on only briefly here.

Each tank is supported by 56 wood and concrete composite piles. The mat type foundation pad is 15 in. thick, 33 ft.-2 in. in diameter, and is reinforced as a two-way flat-slab. One layer of reinforcement only, located 5 in. clear of the slab top was used. Pile embedment is 3 in.

Both tanks are 28 ft. i.d. and approximately 22 ft. high. The circular tank shells are 8 in. in thickness and are hoop reinforced with no. 6 rods at the wall center. Vertical reinforcement consists of no. 4 rods.

The circular walls of these tanks were designed on the basis of triangular load distribution, the top being unrestrained and the base assumed hinged.

The maximum hoop tension was calculated to have a magnitude of 15,570 lb. per ft. and was found to occur at 0.8 of the tank depth. The vertical moment was determined to have a top value of 1190 ft.-1b. per ft. at 0.9 of the tank depth. The shear reaction at the base of the tank wall was calculated to be 1540 lb. per ft.

The design of this type of wall will be covered in more detail in a later section that treats the 128-ft. i.d. settling basin walls.

COAGULATION AND SETTLING BASINS

General

Each coagulation and settling basin, of which there are two, consists of a circular tank 58 ft. i.d. and 18 ft. 4 in. high concentric with another circular tank 128 ft i.d. and 18 ft. high. The inside tank serves as a coagulation tank and is divided into five approximately equal sectors plus an inlet structure. The remaining doughnut shaped area between the inner and outer tanks serves as a long narrow settling basin (see Figs. 2 and 3).

Foundations and Base Slab

Each coagulation and settling basin is supported on 569 wood and concrete composite piles. Of this number 80 are equally spaced in a ring under the outside wall. The remaining 489 are located approximately 5 ft. o.c. on a rectangular grid. Each of the interior piles is topped with a 30-in. diameter by 15-in. concrete cap. The tank floor is a conventional two-way flat-slab. The pile caps serve as column capitals. This floor slab is designed to sustain a uniform total load of 1200 lb. per sq. ft. and varies in thickness from an 8 in. minimum to $11^1/_2$ in. maximum in order to provide

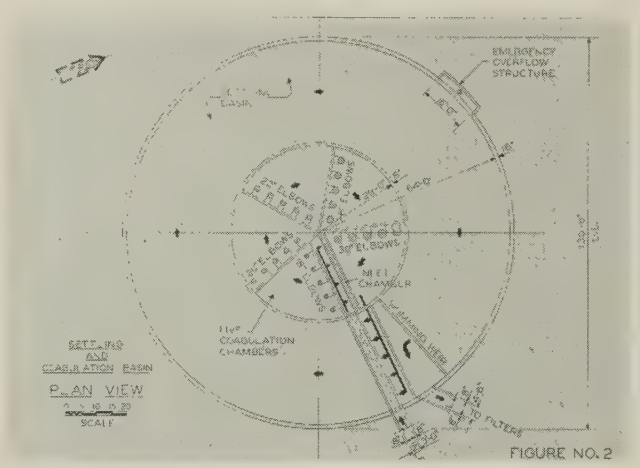

Fig. 2. Plan view of settling and coagulation basin

adequate drainage to the mud valves. The total hydraulic head on this floor is 17 ft. or 1060 lb. per sq. ft.

Coagulation Tank

Each of the chambers of the 58-ft. coagulation tank can be filled independently to a depth of 9 ft. For this reason, the

bottom 9 ft. of the tank wall and the sector dividing walls were designed as modified cantilevers with the tank floor slab as a base. The entire basin must fill to a depth of 9 ft. before any part of it can be filled to a greater depth. Once the 9-ft. level is reached, the entire basin fills uniformly to the 17-ft. level. Since there can be no unbalanced loading on any of the walls of the 58-ft. tank above the 9-ft. level, only nominal temperature and shrinkage reinforcing were required between this level and the top. The tank walls are 12 in. thick at the base and are stepped down to 8 in. at the top.

Settling Basin Wall

The unusual feature of these basins is the construction of the outer wall which has an inside diameter of 128 ft. and must withstand an unbalanced hydraulic head of 17 ft. The type of construction used is seldom seen in tanks of this large size.

The great difficulty encountered in building a concrete tank or basin, to contain a liquid, is to make it water-tight. First the concrete used must be dense enough to prevent the movement of moisture through it. This can be accomplished by careful design of the mix and good control of the placing. Secondly, the occurrence of cracks, through which the liquid may seep, must be prevented. This is a much more difficult problem to solve. In a cylindrical tank, the two principal causes of cracks are shrinkage of the concrete during the curing cycle and ring tension resulting from the thrust of tank loading. This, of course, presupposes a good quality concrete.

The most effective means of making a cylindrical concrete tank water-tight is to "prestress" it. This consists of placing the concrete in the tank wall under compression; horizontally to provide for hoop tension and shrinkage; vertically to care for vertical moment and shrinkage. This method of construction was considered and then rejected because of the extra cost involved. The better prestressing systems are patented, and royalty payments to the patent holders have, up to the present time, made the use of these systems more expensive than other forms of construction.

The wall as it was finally designed is of conventional reinforced concrete construction. It is 18 ft. 9 in. in over-all height and 16 in. thick (see Fig. 4).

It was assumed for the purpose of design that the wall

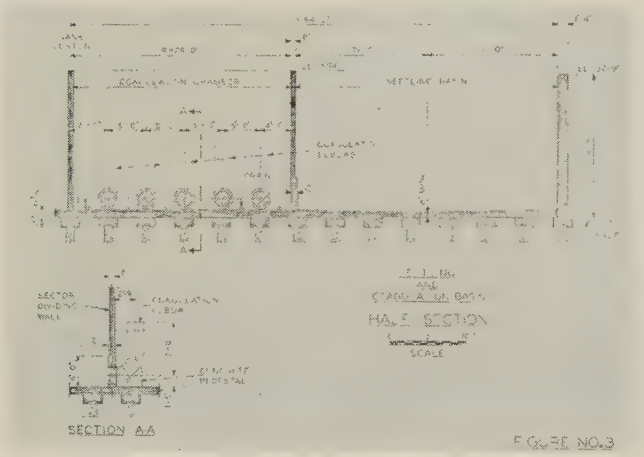

Fig. 3. Half section of settling aid coagulation basin

would have a hinged base, a free top, and that the load distribution would be triangular. Allowance was also made for a moderate radial displacement for the footing (see (*1*) for design procedure followed).

Two objectives stand out in the design of cylindrical tank walls. The wall thickness should be sufficient to keep the concrete from cracking, but if the concrete does crack, the ring steel must be able to carry all the ring tension alone.

The procedure followed in this tank wall design was to provide horizontal steel, A_s, for all the ring tension at an allowable stress, f_s, of 14,000 p.s.i. as though designing for a cracked section. After determining $A_s = T/f_s$, the con-

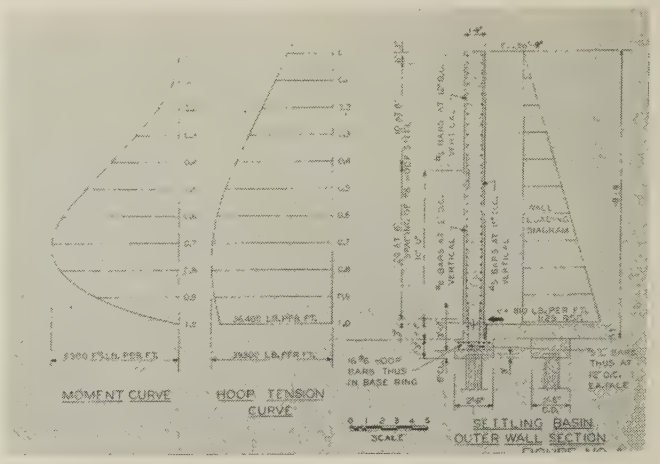

Fig. 4. Outer wall section of settling basin

crete tensile stress in the uncracked section due to combined ring tension and shrinkage was checked by inserting the value of A_s in the following equation:

$$f_c = \frac{CE_sA_s + T}{A_c + nA_s}$$

In which:

- A_s = area of horizontal hoop steel (square inches) for 1 ft. of wall height
- C = concrete shrinkage coefficient (0.0003)
- E_s = modulus of elasticity (pounds per square inch) of the reinforcing steel
- E_c = modulus of elasticity (pounds per square inch) of the concrete
- T = ring tension (pounds) for 1 ft. of wall height
- A_c = area of concrete (square inches) for 1 foot of wall height
- f_c = allowable tensile stress (pounds per square inch) in wall concrete
- n = E_s/E_c

It is generally felt (*2*) that an allowable concrete tensile stress, for cylindrical tank design, of $(1/n)$ (f_c') is a reasonably conservative value when shrinkage is included and ring tension is determined on the basis of a carefully conducted analysis, f_c' being the ultimate compressive strength of the concrete used. In the case we are considering, an f_c' of 3000 p.s.i. was specified. This gives us an allowable tensile stress, f_c, of 300 p.s.i.

It was determined that for the conditions assumed, a maximum ring tension, T, of 39,300 lb. per ft. occurred at 0.75 of the tank depth. It was further determined that a minimum of 2.81 sq. in. of reinforcing steel per foot was required to resist this force. In order to keep the concrete tensile stress within the allowable range, a wall thickness of 16 in. was found to be necessary.

$$f_c = \frac{0.0003 \times 30 \times \overline{10}^6 \times 3.16 + 39{,}300}{16 \times 12 + 10 \times 3.16} = 302 \text{ p.s.i.}$$

The reinforcing selected to resist ring tension was arranged in a double curtain of continuous hoops as shown on Fig. 4.

The maximum vertical moment in the tank wall was found to occur at 0.70 of the tank depth and to have a value of 8300 ft.-lb. per ft. of perimeter. Vertical reinforcing to provide for this moment was placed as indicated on Fig. 4.

The wall is supported on a rigid base ring with an inside diameter of 126 ft. 10 in. and a cross section as shown on Fig. 4.

This ring which is supported on piling at about 5 ft. on centers serves the multiple purpose of supporting the tank wall and the outside edge of the floor slab. It also supports the residual horizontal shear reaction of 1810 lb. per ft. at the base of the wall.

In the construction of the tank wall, the allowable stress

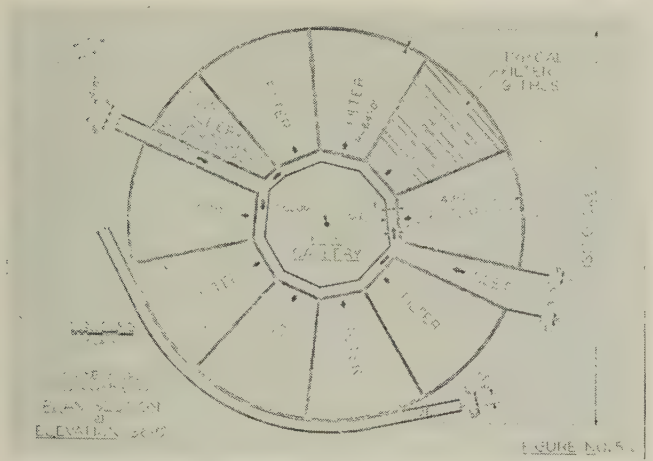

Fig. 5. Filter house and clear well plan section at elevation 36 ft.

in the hoop bars that carry ring tension was reduced from 20,000 to 14,000 p.s.i. to minimize the width of any cracks that might develop. Also, the use of type II low heat cement was specified to reduce the possibility of shrinkage cracks.

In order to conserve forms, the wall was poured in eight separate pours of approximately 50 lineal ft. each. The concrete was kept wet with a water spray for 7 days.

FILTER HOUSE AND CLEAR WELL

General

The circular structure that houses the rapid sand filters and the clear well is quite unique. It has an inside diameter of 128 ft. and is 25 ft. 4 in. from the top of the base slab to the top of the outside wall. The arrangement of the various elements of this structure is shown on Figs. 5, 6, 8, and 9.

The single most unusual feature of this building is the use of two *three-way flat-slabs*. One serves as the building foundation and the other supports the filters, pump gallery, and pipe gallery. This structure presented the author with his first opportunity to use this type of construction and to his knowledge, there are few other slabs of this type in existance. A flat-slab floor consists of a reinforced concrete slab supported directly on concrete columns without the aid of beams or girders (*3*). A three-way flat-slab differs from a conventional two-way flat-slab in that the supporting columns are arranged on a triangular rather than a rectangular grid. This makes it particularly adaptable to a circular layout. The reinforcing in a three-way flat-slab is radically different from that of a two-way slab.

The design of this type of slab is actually a modification of the design of a circular slab with center and edge support only, the continuous edge support being replaced by the six columns that lie on a concentric circle around each column of the system (see Fig. 6). In general, flat-slab construction is economical for live loads of 100 lb. or more per sq. ft. and for spans up to about 30 ft. (*3*).

Foundations

Supporting this tanklike building are 1204 pilings. Of these, 160 are equally spaced on a 129-ft. diameter ring under the outside wall. The balance are arranged on a rectangular

NOMENCLATURE

A_c	=	area of concrete, square inches
A_s	=	area of steel, square inches
C	=	concrete shrinkage coefficient
f_c	=	concrete stress, pounds per square inch
f_c'	=	ultimate compressive stress, pounds per square inch, in concrete
f_s	=	steel stress, pounds per square inch
E_c	=	modulus of elasticity, pounds per square inch, of concrete
E_s	=	modulus of elasticity, pounds per square inch, of steel
n	=	E_s/E_c
p.s.f.	=	pounds per square foot
p.s.i.	=	pounds per square inch
V	=	shearing force, pounds
M	=	bending moment, foot-pounds
T	=	ring tension, pounds
i.d.	=	inside diameter
o.d.	=	outside diameter
o.c.	=	on center

grid and spaced on about 3.5-ft. centers. The 131-ft. 6 in. o.d. mat-type foundation is an inverted three-way flat-slab which serves also as the clear well floor slab. This 20-in. thick slab contains 840 cu. yd. of concrete and represents the largest single pour in the plant. The effective depth of the the slab for maximum shear and moment is 12 in. The remaining 8 in. is utilized to provide for pile embedment and steel protection and arrangement. The design procedure followed is that given in (*4*). The design load is an unbalanced upward force of 1100 lb. per sq. ft. The 1000-lb. per sq. ft. load from the water in the clear well and from the base slab itself is carried to the foundation piling by direct bearing alone.

The maximum design moment provided for is the radial moment occurring at the edge of the column capitals and has a value of 31,800 ft.-lb. per ft. Unit shear at this same section was calculated to be 91 p.s.i. This is a maximum for the slab.

Figure 7 illustrates the arrangement of the reinforcing steel in this slab.

Clear Well Wall and Filter Support Columns

Rising from the foundation slab are 37 spirally reinforced round columns and the cylindrical outside wall of the structure.

The columns are 18 in. in diameter, 12 ft. long, and have a

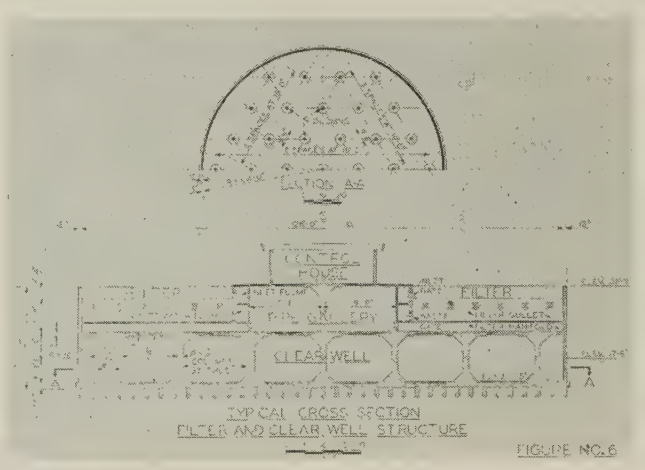

Fig. 6. Typical cross section of filter and clear well structure

6-ft. diameter mushroom head at either end. They are spaced 19 ft. on centers on a triangular grid with origin at the tank center. This unusual arrangement was selected because the pattern formed is roughly concentric with the tank wall (see Fig. 6). A rectangular grid would not fit well into a circular layout of this size.

The cylindrical wall that encloses the clear well is 128 ft. i.d., 12 ft. 4 in. high, and 12 in. thick (*5*). It is restrained against horizontal movement at the top by the filter floor slab and at the bottom by the clear well base slab. A hinged base is provided while the wall top is monolithic with the filter slab and the outside wall of the filters. The water in the clear well produces a hydraulic loading at the inside wall face varying from zero at the top to 750 p.s.f. at the base. A maximum moment of 11,000 ft.-lb. per ft. is produced at the wall top due to loading on the filter deck. In addition the wall carries its proportionate share of the vertical loads from the filter deck.

The wall is hoop reinforced to provide for the main circumferential stresses. Reinforcing is also placed to care for the vertical wall moment. The maximum hoop tension was calculated to be 17,000 lb. per ft. at mid-height of the wall and the vertical moment was determined to have a top value of 11,000 ft.-lb. per ft. of perimeter (see Fig. 8).

This wall, like those in the settling basins and mix tanks, was proportioned to keep the concrete tensile stress in the uncracked section below (l/n) (f_c'), which in this case equals 300 p.s.i. An f_s of 14,000 p.s.i. was again used in the hoop steel.

Filter Floor Slab

Resting atop the clear well wall and the 37 interior columns is the second three-way flat-slab in this structure (*4*). This slab doubles as the clear well roof and the floor that support the nine filters, the pipe, and pump galleries. It is similar in construction to the clear well base slab and is 12 in. thick except at the support columns where the use of a 4-in. deep by 10-ft. diameter drop panel increases the over-all thickness to 16 in. The reinforcing system is similar to that used in the base slab except that in this instance it has been reversed; the reason being that the load in this case, is applied from the top instead of the bottom. In addition to the reinforcement necessary to provide for the uniform load of 1000 lb. per sq. ft., provision was also made to care for the moments induced in the slab by the filter dividing walls and the manifold walls. The design of this slab was further complicated by the fact that four rectangular openings 5 by 7 ft. had to be framed into it in the pump gallery area to provide mounting space for the filtered water pumps. The outer edge of this

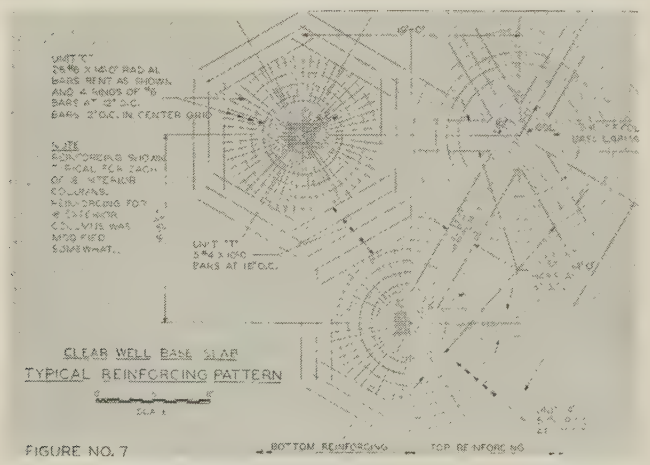

Fig. 7. Typical reinforcing pattern of clear well base slab

128-ft. diameter slab is monolithic with the cylindrical outer wall of the structure.

Filters

The construction of the walls that rise from the filter deck support slab is conventional and there is no need to dwell on the matter at any length here. It is, however, of interest to note that the side walls of the filter wash troughs have been extended through the filter gullets and act as structural ties between the filter side walls. This feature materially reduces the moments that would otherwise be induced in the supporting slab under certain loading conditions. This made possible a material saving in the construction of the slab (see Figs. 5 and 9).

Control Deck Slab

The final feature of this structure that merits some special

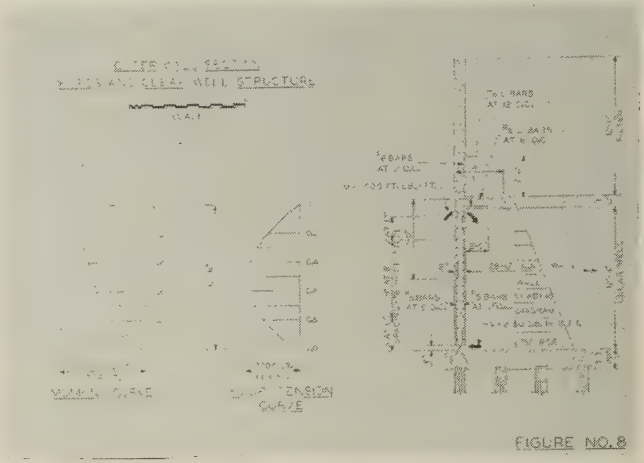

Fig. 8. Outer wall section—filter and clear well structure

attention is the slab that serves both as a roof over the pipe gallery and a floor for the control room (see Figs. 5 and 6). The problem here was to find a rational method of supporting the slab. The solution finally arrived at is outlined below.

This slab is approximately 40 ft. in diameter and is supported at its center and perimeter only (*6*). The center column is 18 in. in diameter and has a 6-ft. diameter mushroom capital. A 4-in. by 10-ft. diameter drop panel was also required. The slab thickness at the edge of the column capital is 13 in. and at the edge of the drop panel 9 in., from which it tapers to 7 in. at its outside edge. The perimeter of this slab is supported by the 6-in. partition wall between the pipe gallery and the inlet and waste water flumes.

There is a 4-ft. 3-in. diameter stair well and a 5-ft. 4-in. diameter access hatch through the slab 6 ft. 0 in. and 6 ft. 11 in. from the slab center, respectively. These openings are 126° apart.

The main reinforcing consists of radial bars placed near the top of the slab at the supports and near the bottom at mid-span. The secondary or tangential reinforcing consists of continuous hoops placed concentrically about the slab center and at the same slab face as the main radial reinforcement.

The primary loads carried by the slab consist of the dead load of the slab itself, the control house structure, the eleven automatic control panels, and such live loads as might normally be expected to be applied. The design loading used was a uniform total load of 280 lb. per sq. ft. The maximum moment and shear for this design load occur at the edge of the column capital. They have a magnitude of 14,300 ft.-lb. per ft. and 4700 lb. per ft. respectively.

Adoption of this design provided a pipe gallery 40 ft. in diameter with a vertical clearance of 12 ft. with but a single interior column. The use of the flat-slab also materially simplified the form work required by eliminating the beam system that would otherwise have been necessary.

CONCLUSION

The really novel features of this water treatment plant from the structural viewpoint are the settling basin walls, the two three-way flat-slabs used in the clear well and filter

house, and the control room floor slab. Each of these features represents a type of structure seldom, if ever, encountered in the daily course of events. Each also represents a timely solution to a problem peculiar to the circular layout of this plant.

To the best of the author's knowledge, this filter plant, with

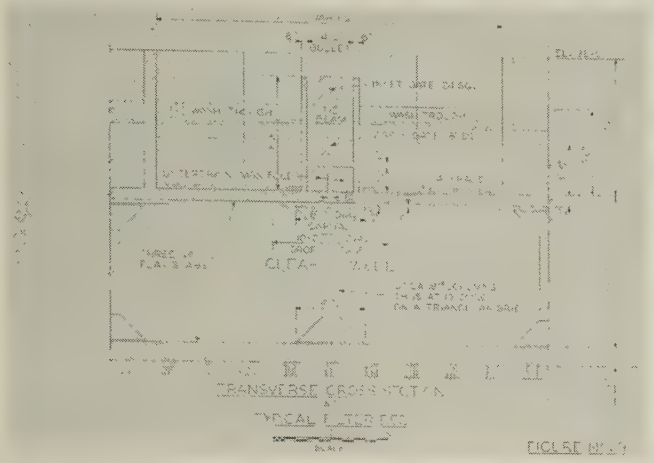

Fig. 9. Transverse cross section at typical filter bed

reference to its circular layout, is the first of its type. Some of the structural problems presented were unusual as were their solutions. A great deal of valuable structural information was gleaned in the course of working out this desigr. Currently, the author is engaged in the design of another similar plant and the knowledge gained in designing the facility here discussed is helping to provide a better structure at a lower cost per gallon of water treated.

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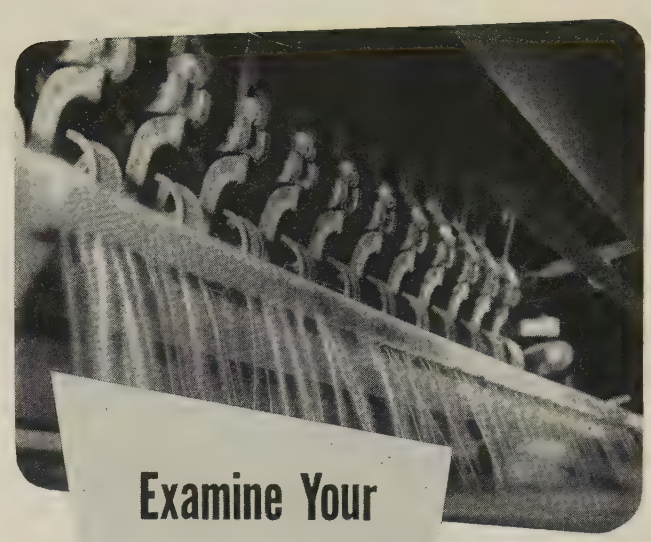

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Neutral Sulphite Semichemical Recovery Systems

RODERICK O'DONOGHUE

It is the intent of this discussion to deal primarily with the recovery of the values in spent cooking liquors from the neutral sodium sulphite semichemical pulping process. Production of semichemical pulp is increasing rapidly, and the problem of chemical recovery is becoming of increased importance, not only because of the value of the recovered chemicals, but also, and in many cases primarily, because of the necessity of avoiding stream pollution.

Heretofore, there has been no practical solution to this problem, however, much study and effort have been devoted to it both in this country and abroad, resulting in a number of systems worthy of consideration. After a general review of the patents and literature, the following systems have been chosen for discussion:

I—Mead process.....Sponsored by the Mead Corp.
II—Sivola process.....Sponsored by Combustion Engineering Co.
III—"Sulfox" process.....Sponsored by Robert Aries and Arthur Pollak
IV—"Institute" process..Sponsored by the Institute of Paper Chemistry

The above processes constitute a group which have in common the burning of concentrated black (or brown) liquor. The processes are each unique in the method of chemical recovery from the resulting "green liquor."

V—Zimmerman process..Sponsored by the Sterling Drug Co.
VI(a)—Bickel & Trithaway process
(b)—Rayonier process

Processes under VI(a) and (b) are ion exchange processes and are not discussed in detail, but may merit consideration though disclosure of results to date is limited. Neutral sulphite semichemical liquor direct from washers is treated in two stages of carboxylic and sulphonic resins. These are regenerated by sulphurous acid. Sodium sulphite, which must be neutralized with sodium carbonate is recovered. An appreciable fraction of the soda is thus lost.

VII—Hydrotropic pulping process..Sponsored by Ralph H. McKee

The Mead process was worked out in a pilot plant installed at the Mead Corp. mill at Sylva, N. C. Full details of the results have not been generally disclosed.

The Sivola process as sponsored by Combustion Engineering Co. was developed by George Sivola, consulting engineer of Finland, and has been installed in the Rauma Repola, Oy pulp mill in Rauma, Finland. However, this mill is making a high grade dissolving pulp using a two-stage cooking process with a sodium bisulphite cook, neutralization with sodium carbonate, and an alkaline final stage. Therefore, the recovery system at this mill is somewhat different than that shown on Fig. 1.

The "Sulfox" process as developed by Robert Aries and Arthur Pollak is based on direct oxidation of the sodium sulphide as explained in detail below. It would be necessary that this reaction be properly handled to prevent excessive production of sodium sulphate and thiosulphate. No commercial installation has been made to date.

The "Institute" process was developed by The Institute of Paper Chemistry, its membership group being interested in the solution of the problem. Instead of building a pilot plant, kraft recovery facilities were made available at the Tomahawk, Wis., mill of National Container Corp. This equipment was used to develop a recovery system for the existing semichemical pulp mill using neutral sodium sulphite cooking liquor. This plant is in operation on a production scale. Complete details of the process have not been disclosed so that the flow diagram and data given in Fig. 2 give only a general idea of the cycle.

The Zimmerman process is installed and operating, in part, at the semichemical mill of the Hammermill Paper Co. at Erie, Pa. Referring to the flow sheet (Fig. 3) covering the process, the existing plant, though built on a production scale, is not arranged to make power, but does produce process steam. Complete detail is not disclosed.

Although Professor McKee's hydrotropic process used a different cooking chemical, it is included because of its unique and comparatively simple recovery system. The outstanding feature is that a recovery furnace is not used as a part of the process and that the lignins are recovered by "salting out" on dilution and taken off as a cake on a vacuum washer. It can then be burned as a fuel or used otherwise.

The author's company is studying comparative costs of systems outlined, but the author does not feel this information should be part of this article.

MEAD PROCESS

This process has been operated only on a pilot plant scale at the Sylva, N. C., plant. It has the merit of relative simplicity in equipment and operation.

Concentrated black or "brown" liquor is burned in the conventional manner as applied in kraft mill practice. In smaller plants the recovery unit could consist solely of a water-cooled furnace at lower investment cost.

Green liquor is made from the smelt in the usual manner. This liquor is clarified and sent to storage: weak liquor from the dregs washer being returned to the smelt tank where it serves for dilution.

Products of combustion and clarified green liquor are then treated in a series of carbonating and SO_2 absorption towers.

It is not considered advisable at this time to give further details and a flowsheet of the system.

SIVOLA PROCESS

This process is a proposed adaptation of the Sivola process now in use at the plant of Rauma Repola, Oy, Rauma, Finland, making low yield high quality, soda-base sulphite pulp. It is one of a group of systems which contemplate the burning of concentrated semichemical black liquor with the production of green liquor in the conventional manner.

The initial recovery equipment, though only about one third to one half the size required by a kraft pulp mill of the same daily output, is basically identical in character, and consists of a recovery boiler with smelt dissolving tank, a cascade evaporator, and an electrostatic precipitator.

Green liquor in normal concentration of 20 to 21% total solids is clarified and cooled, weak liquor being returned to the smelt tank from the dregs washer (dissolved solids in clarified green liquor are normally 70% Na_2S and 30% Na_2CO_3). The clarified green liquor is then treated in what may be termed primary and secondary treatments.

The basic chemical equations applying in the primary and secondary elements are as follows:

$$Na_2S + 2H_2O + 2CO_2 = 2NaHCO_3 + H_2S \quad (1)$$

$$Na_2CO_3 + CO_2 + H_2O = 2NaHCO_3 \quad (2)$$

Sulphur dioxide from burning of make-up sulphur and the combustion of released hydrogen sulphide from equation (1) is absorbed as follows:

$$Na_2SO_3 + SO_2 + H_2O = 2NaHSO_3 \quad (3)$$

The primary treatment takes place in two packed towers, one a "precarbonating" tower where the clarified green liquor runs countercurrent to a sulphur dioxide-free fraction of the recovery boiler flue gases. The sulphur dioxide-free flue gas

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is in turn obtained by countercurrent scrubbing with "mother liquor" in a packed gas scrubber. Dilute hydrogen sulphide is given off in the "precarbonating tower" and sent to the recovery boiler chimney. "Make-up" carbon dioxide is thus captured from flue gas.

In the main carbonating tower green liquor runs countercurrent to relatively pure carbon dioxide from a gasometer, completing equations (1) and (2), and resulting in a slurry of sodium bicarbonate crystals in a "mother liquor" of sodium carbonate, sodium bicarbonate, and some sodium sulphide. From the top of the carbonating tower fairly concentrated hydrogen sulphide from equation (1) is sent to the sulphur burner to be burned along with make-up sulphur.

In a packed tower the sulphur dioxide is absorbed in sodium sulphite to form sodium bisulphite. The acid sulphite is mixed with the bicarbonate slurry from the main carbonating tower and bicarbonate make-up, reacting thus:

$$NaHSO_3 + NaHCO_3 = Na_2SO_3 + H_2O + CO_2$$

This carbon dioxide plus the digester relief is stored as fairly pure carbon dioxide in a gasometer. One half the sodium sulphite is sent to cooking liquor storage and one half to the sulphur dioxide absorber for recycling and formation of sodium bisulphite. Cooking liquor is heated and sent to storage.

While the quantity and B.t.u. value of the solids in semichemical black liquor will vary with the type of cook and the yield of pulp, experience indicates that total solids in the black liquor from high yield pulp preparation will vary between 1000 and 1100 lb. per ton of pulp, and that the average B.t.u. value will be about 4500 to 5000 B.t.u. per lb. of dry solids. Steam production on this basis is predicted at about 2.0 lb. per lb. of dry solids in the black liquor or 2000 to 2200 lb. per ton of pulp.

It is predicted that recovery of soda will be in the order of 95 to 97% of that in the black liquor if a cascade evaporator and precipitator are installed. Under these conditions, a sulphur make-up of 40 to 50 lb. per ton of pulp is predicted.

SULFOX PROCESS

The Sulfox process (see Fig. 4) for the recovery of chemical values in neutral sulphite semichemical black liquor contemplates the concentration and burning of the black liquor in the conventional manner. Final concentration of the black liquor and secondary fume recovery are accomplished in a cascade evaporator and electrostatic precipitator or equivalent means. The production of "green liquor" by dissolving the resulting smelt in water mixed with some recycled sodium sulphide solution takes place in a conventional agitated "dissolving tank."

In the Sulfox process the concentration of sodium sulphide as drawn off from the dissolving tank is about 25 to 30% Na_2S, slightly higher than in normal kraft mill operation. This high concentration of sodium sulphide causes some "salting out" of sodium carbonate. The slurry is transferred to a "settling tank" where the required quantity of mother liquor (strong in sodium sulphide) is drawn off with the sodium carbonate slurry for oxidation of the sodium sulphide. The balance of the mother liquor is recycled to the dissolving tank where diluted with water it is ready to receive additional "smelt."

The sodium carbonate in a neutral sulphite semichemical pulp mill constitutes an inactive but unavoidable cycling material, averaging 40% of the total solids in the green liquor. A small quantity of sodium sulphate is similarly present and inactive, being continuously formed in the furnace and ultimately arriving at a stable fraction approximating 8 to 10% of the total solids.

The Sulfox process treats only the sodium sulphide which is present in the slurry in the proportion of 1 part sodium sulphide to 3 parts of total water in the solution. The sodium sulphide is oxidized to sodium sulphite after the following equations:

$$2Na_2S + 2O_2 + H_2O = Na_2S_2O_3 + 2NaOH \quad (1)$$

$$3Na_2S_2O_3 + 6NaOH = 4Na_2SO_3 + 2Na_2S + 3H_2O \quad (2)$$

The sodium sulphide formed in equation (2) is further oxidized according to equation (1).

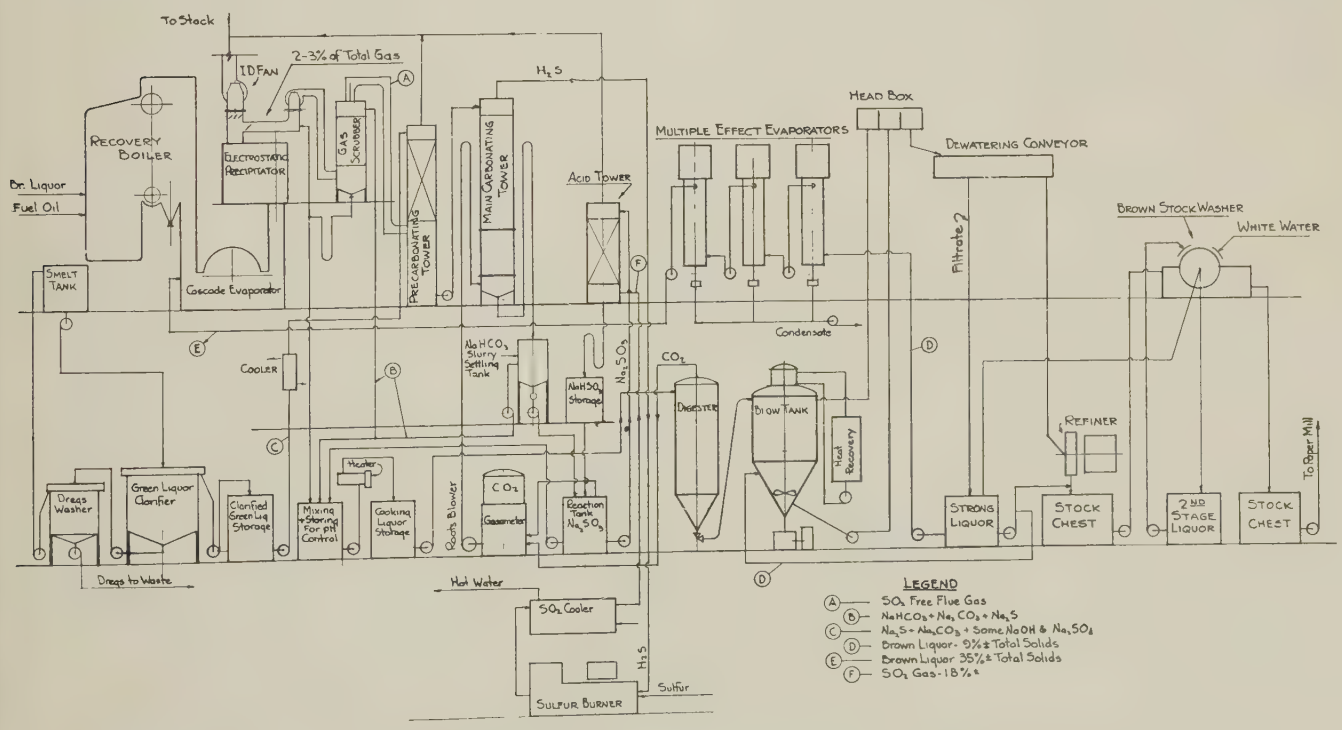

Fig. 1. Sivola recovery process applied to a 100-ton-per-day neutral sulphite semichemical pulp mill

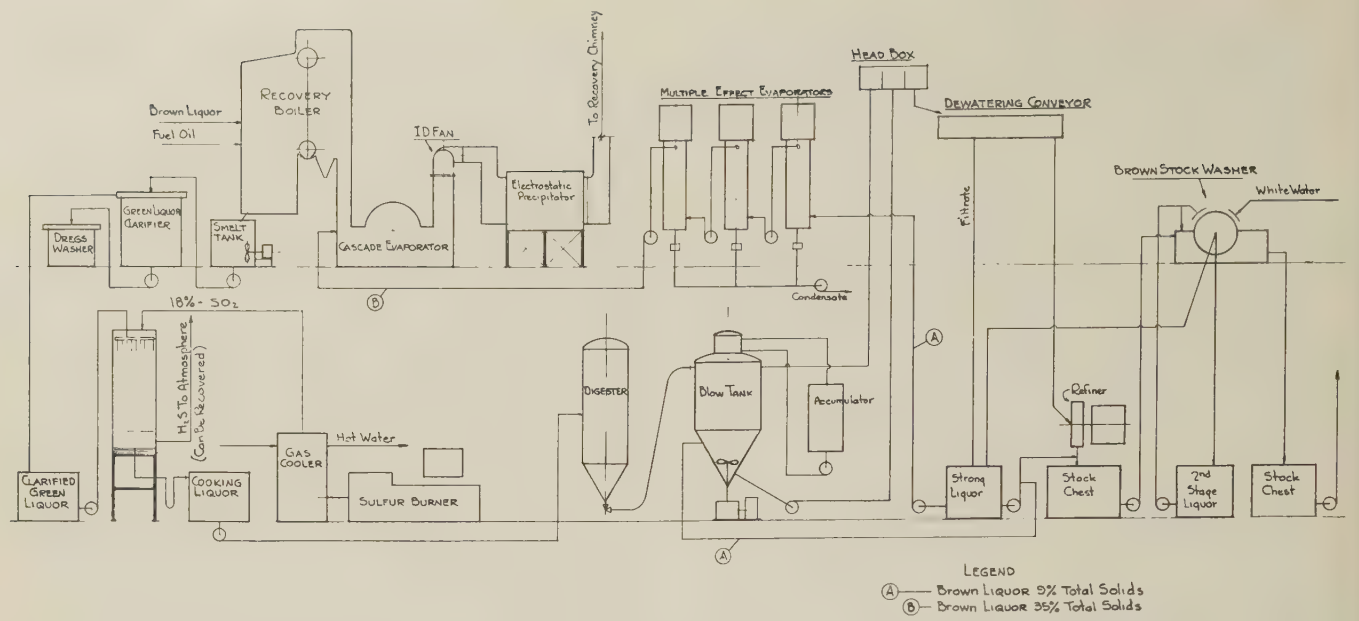

Fig. 2. Institute of Paper Chemistry recovery process applied to 100-ton-per-day neutral sulphite semichemical pulp mill

The oxidation, which is exothermic, is accomplished in a suitable reactor with air preheated to 320°F. It is suggested that the reactor should be in the form of a rotary kiln.

In order to secure proper physical condition to assure good contact between the air and material being oxidized about 90% of the finished sodium sulphite is recycled and mixed in powder form in a pug mill with the kiln feed from the settling tank. About 10 lb. of sodium sulphite powder is recycled per pound of water in the slurry, producing a relatively dry and "open" mixture. Properly operated, oxidation of sodium sulphide is complete.

Approximately 80 cu. ft. at 60°F. of free air per pound of sodium sulphide will provide the required oxygen (with 100% excess). As noted above the reaction is exothermic, releasing about 3000 B.t.u. per lb. of sodium sulphide oxidized. This heat is sufficient to vaporize virtually all the water in the original with some excess which is lost to radiation. Auxiliary cooling may be required. The air, partially depleted of oxygen plus the resulting water vapor, constitute a total gas volume leaving the kiln of approximately 1700 c.f.m. at 320°F. It is suggested that the gas velocity in the kiln should not exceed 60 f.p.m. based on the gross kiln area. It is further suggested that the material which weighs 30 lb. per cu. ft. should occupy 15% of the kiln area. Retention time is given as 1 hr. A 100 tons per day pulp mill would thus require a kiln about 7 ft. diameter by 100 ft. long.

There will be some carry-over of finished sodium sulphite with the kiln discharge gases and it is believed that bag filters or a spray washer would recover sufficient dust to justify their use.

Soda is lost in the pulp mill cycle, and may be made up (1) by adding salt cake to the furnace, (2) by adding sodium sulphite to the cooking liquor, or (3) as recommended by adding sodium carbonate or sodium bicarbonate to the cooking

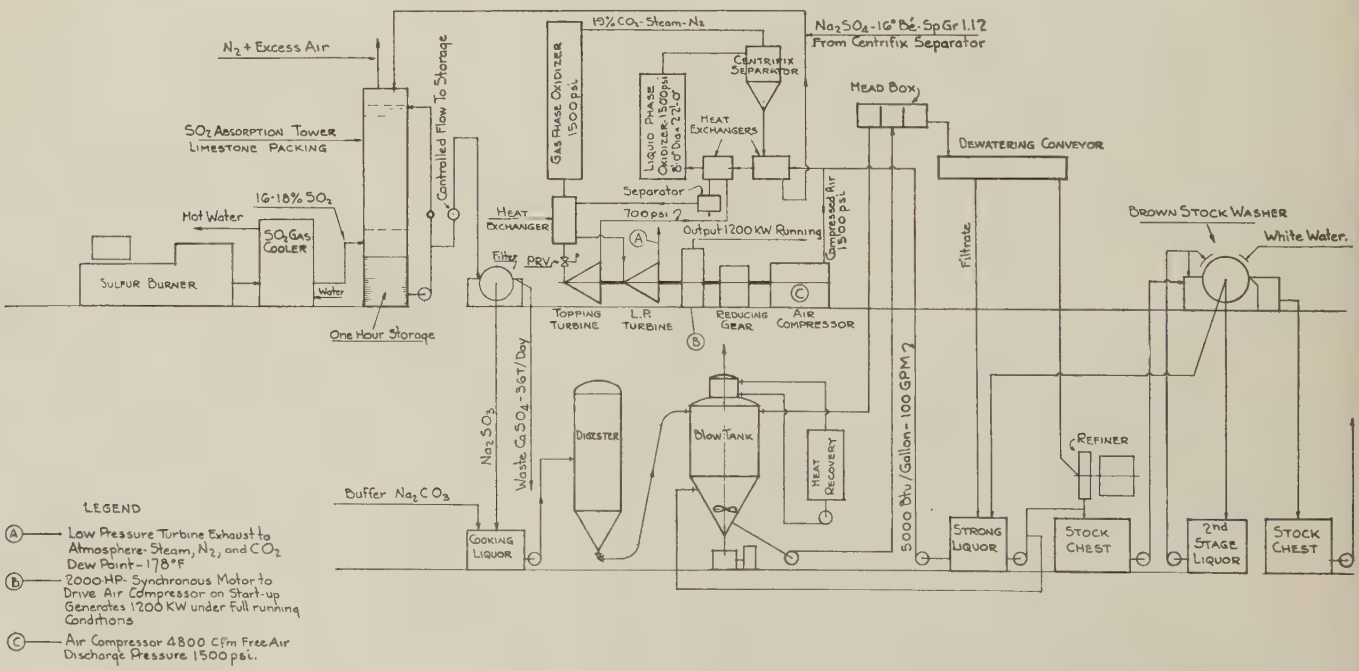

Fig. 3. Zimmerman recovery process for a 100-ton-per-day neutral sulphite semichemical pulp mill

liquor, the sulphur loss being made up by scrubbing sulphur burner gas, cooled to about 70°F. with the cooking liquor.

The total over-all soda recovery is given as 95%, referred to the spent liquor, good pulp washing being assumed.

Recovery of sulphur is given as approximately 45 to 50% referred to the spent liquor with no sulphur dioxide recovery from recovery furnace flue gases. If the recovery furnace gases are scrubbed in a short packed tower, 90% of the sulphur in the flue gases can be recovered, raising the over-all recovery to 70% referred to spent liquor. Experience indicates that not over 90% of the sulphur in the flue gas is readily recoverable. Too efficient scrubbing may result in the formation of undesirable sulphates. Study is required to determine whether this final scrubber can be economically justified.

THE INSTITUTE OF PAPER CHEMISTRY PROCESS

This process has been worked out by The Institute of Paper Chemistry and is being sponsored by them, under patent protection at present confining its use to member companies. It is described as "A one-step liquid phase sulphitation process." In this process, a "green liquor" is formed by dissolving the smelt from a conventional recovery boiler—the total solid content of the green liquor being held at approximately the normal 20% total solids used in kraft mill practice.

The green liquor is clarified, weak liquor being returned to the smelt tank from the dregs washer. The clarified green liquor then enters the top of a packed tower in parallel flow with about 18% SO_2 gas from a sulphur burner which has been cooled to 70°F. The following reactions take place:

$$Na_2CO_3 + H_2O + SO_2 = Na_2SO_3 + CO_2 + H_2O \quad (1)$$

$$Na_2S + 2NaHSO_3 = 2Na_2SO_3 + H_2S \quad (2)$$

$$Na_2CO_3 + 2NaHSO_3 = 2Na_2SO_3 + CO_2 + H_2O \quad (3)$$

$$Na_2SO_3 + H_2O + SO_2 = 2NaHSO_3 \quad (4)$$

$$Na_2CO_3 + CO_2 + H_2O = 2NaHCO_3 \quad (5)$$

$$2Na_2S + 2O_2 + H_2O = Na_2S_2O_3 + 2NaOH \quad (6)$$

$$2NaOH + SO_2 + H_2O = Na_2SO_3 + 2H_2O \quad (7)$$

$$3Na_2S_2O_3 + 6NaOH = 4Na_2SO_3 + Na_2S + 3H_2O \quad (8)$$

The sodium acid sulphite (Na_2HSO_3) produced in equation (4) is further reacted with sodium sulphide as in equation (2) to form sodium sulphite (Na_2SO_3). The complete reaction represented by equations (2) and (4) may for convenience be written as:

$$Na_2S + SO_2 + H_2O = Na_2SO_3 + H_2S$$

The hydrogen sulphide is discharged from the bottom of the packed tower accompanied by the products of combustion from the sulphur burner, largely nitrogen, but with some oxygen unabsorbed per equation (6), and some carbon dioxide formed in reaction (3) and not absorbed in reaction (5). While it is possible that sulphur could be recovered from the dilute hydrogen sulphide economically it does not appear to be justifiable.

Reference to equation (6) indicates that sodium thiosulphate ($Na_2S_2O_3$) will be formed by contact between sodium sulphide and oxygen in excess combustion air. Some sodium sulphate may be similarly formed. It is said that concentrations of thiosulphate below 25% of total solids will not affect bleachability of pulp. At least in part, the end products of reaction (6) may complete reaction (8) thus minimizing production of thiosulphate. Reaction (6) emphasizes the necessity for keeping excess air at an absolute minimum in the sulphur burner. It also indicates the impossibility of reburning the dilute hydrogen sulphide in the sulphur burner with consequent recycling of increased combustion products.

As it is now proposed to operate, about all the sulphur is lost—50% in the hydrogen sulphide discharged from the reaction tower and 50% in the recovery boiler. It is claimed that sulphur may be largely reclaimed by burning hydrogen sulphide in recovery boiler with the installation of a precipitator. All soda except that lost in washing and burning is recovered. If a precipitator is installed soda losses would approach those in kraft mill operation.

Make-up soda is added in the form of soda ash to the clarified green liquor storage, make-up sulphur, of course, being added in the form of sulphur dioxide from a sulphur burner.

It is obvious that the process, in general, parallels that by Bradley and McKeefe covering treatment of green liquor with sulphur dioxide certain procedure designed to suppress thiosulphate formation constituting a special feature.

ZIMMERMAN PROCESS

The Zimmerman process (as applied to a 100-ton-per day neutral sulphite semichemical pulp mill) treats the concentrated black liquor from washing the pulp without using evaporators.

Black liquor together with 4800 c.f.m. of compressed air are forced at 1500 p.s.i.g. and at a temperature exceeding 525°F. into a reaction chamber. Here, at the elevated pressure and temperatures, oxidation of the inorganic sodium sulphide to sodium sulphate, together with partial oxidation and partial

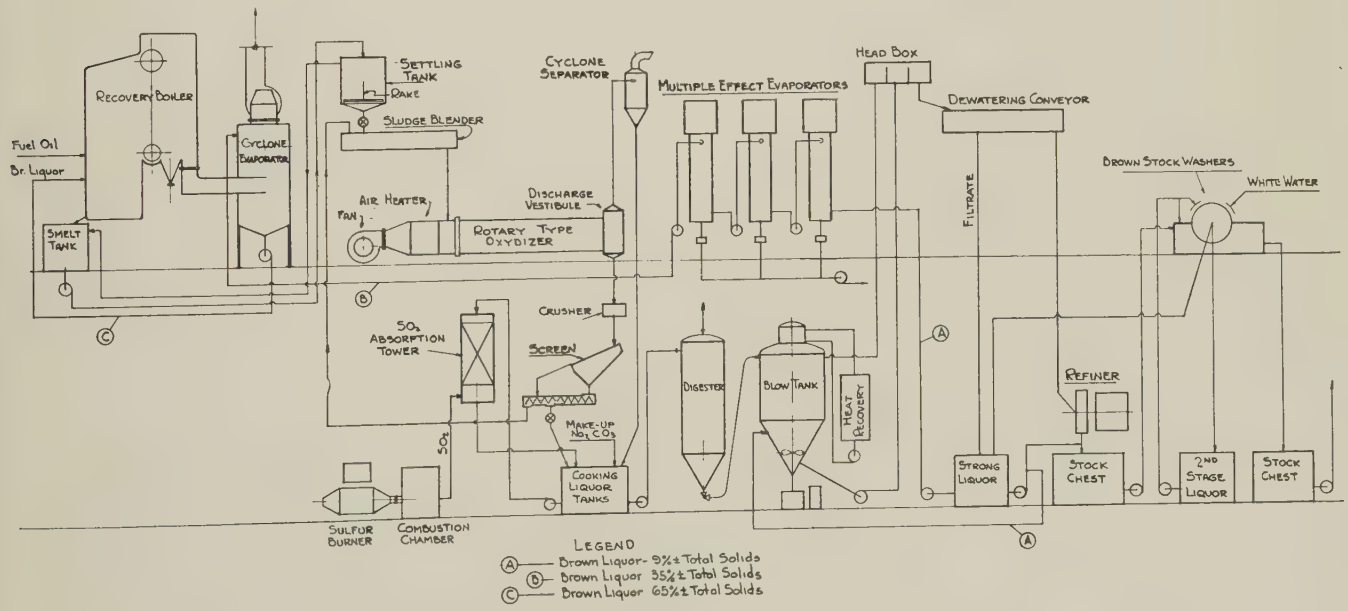

Fig. 4. Sulfox recovery process

cracking of the organics take place, producing heat which results in a mixture of steam and noncondensable gases having a carbon dioxide content approaching 19%. (The compressed air supply is only very slightly in excess of the theoretical.)

Ebullition in the reactor causes priming of the solution, the resulting total products passing out to a centrifix or similar separator where the hot sodium sulphate solution is drained off. The steam and noncondensable gases pass on to a "gas phase oxidizer" were the oxidation of the organic gases continues to completion. Reactor efficiency is said to be 90% of theoretical.

The mixture of steam and noncondensable gases from the gas phase oxidizer drives two turbines on a single shaft, one topping and one low pressure unit. These turbines drive the air compressor through appropriate speed reduction. Interposed on the extended turbine shaft is a 2000-hp. synchronous motor which on start-up will drive the air compressor and which under running conditions will act as a generator feeding back about 1200 kw. to mill use.

The sodium sulphate solution from the centrifix separator is recycled back to the top of a limestone packed absorption tower where it drops countercurrent to 16 to 18% SO_2 gas from a sulphur burner which has been cooled to about 70°F. The following reactions take place:

$$Na_2SO_4 + CaSO_3 + H_2O + SO_2 = 2NaHSO_3 + CaSO_4 \quad (1)$$

(Calcium sulphate is waste—sulphur content is equal to total sulphur input less losses. There is no sulphur recovery.)

$$2NaHSO_3 + CaCO_3 = Na_2SO_3 + CaSO_3 \quad (2)$$

Or the following reaction using burned lime:

$$2NaHSO_3 + Ca(OH)_2 = Na_2SO_3 + CaSO_3 + 2H_2O \quad (3)$$

(The calcium sulphite from equations (2) and (3) cycles back to equation (1).)

The resultant sodium sulphite solution is filtered, buffered as desired with sodium bicarbonate, and stored as cooking liquor. As noted above there is no sulphur recovery. The recovery of soda is said to be about 65% of that fed to the system in the black liquor. Soda make-up may be made as soda ash to the absorption tower or as buffering material above noted.

It is claimed by the inventor that one man can operate the complete recovery plant equipment.

HYDROTROPIC PROCESS

While the hydrotropic process of pulp preparation (see Fig. 5) has no resemblance to the neutral sulphite semichemical process, it is discussed here since it appears that pulp of similar quality can be produced thereby with economical chemical recovery, with comparable yield, and without objectionable effluent or odors.

The active chemical (sodium xylenesulphonate—$NaXSO_3$) does not itself react chemically with the lignins and pentosans of the material being pulped, it acts as a physical catalyst causing these normally insoluble materials to become readily soluble. The solubility of the lignins in the cooking liquor increases with increased concentration of the chemical, the increase in lignins solubility being much greater than the increase in base chemical concentration. The pulp is washed in approximately the conventional manner and about 80% of the black liquor is returned to the digesters. The balance of the black liquor is sent to the recovery operation.

Recovery of the black liquor chemicals is accomplished by dilution when by "hydrotropic" action the lignin is precipitated at about 200°F., washed to recover entrained chemicals, partially dried and used as fuel in the boiler, supplying fully the fuel requirement of the pulp mill. The cooking liquor is restored to its original concentration in multiple effect evaporators. The evaporator load is estimated to be only about one third of that required in the concentrating of black liquor in a neutral sulphite semichemical operation of the same size. No heavy liquor burning or green liquor operations are required.

The process makes available carbon dioxide and furfural as by-products from the digester blow. The furfural may be recovered at some profit. The amount available is, however, dependent on the type of wood and yield of pulp and this factor would require study. It should be noted that, even if furfural recovery is not attempted, there is no problem created by its discharge to the atmosphere, as in a sulphur cook, since the odor is rather pleasant.

Make-up of the active chemical (sodium xylenesulphonate) is claimed to be in the order of 20 to 30 lb. per ton of pulp using

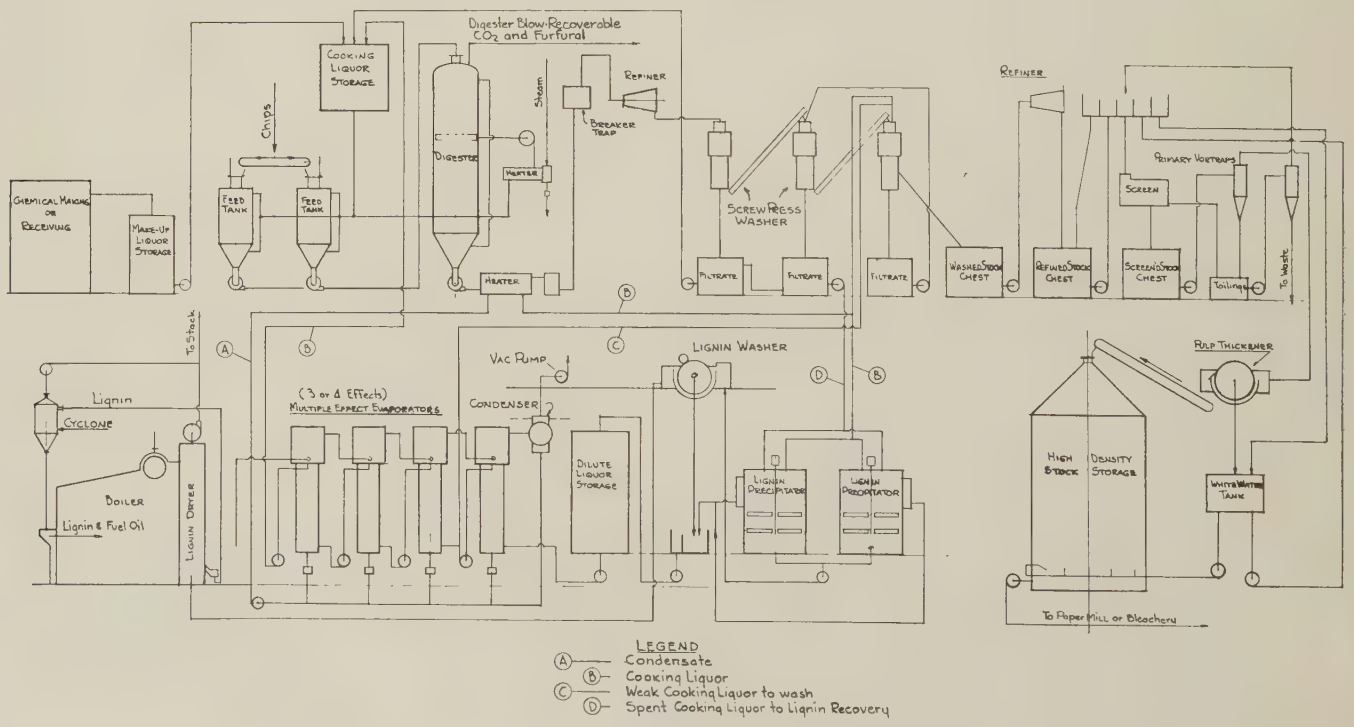

Fig. 5. Hydrotropic pulping and chemical recovery

a short cook. The chemical can either be made at the mill from xylene, caustic soda, and sulphuric acid, at an estimated cost approximating 5¢ per lb. or it may be procured as 40% solution at a higher price on the solid basis. Estimates indicate that chemical cost should approach $3.00 per ton of pulp.

Technical Manpower and Technical Information

T. T. COLLINS, JR.

RECENTLY there has been considerable publicity given to the so-called "shortage" of engineers and scientists being trained in the United States when viewed in the light of future requirements and the concentration on technology of our competitor, the U.S.S.R. In an earlier paper (*1*) were discussed the various aspects of the situation and some of the reasons for it. Table I summarizes figures on technical man power in the two countries.

Various factors in the Soviet Union such as lack of competitive pressure to use a preponderance of engineers in manufacture of products for civilian use; forced placement of graduates in the technical field; elimination of need for sales engineers, etc.; accessibility of technical information from other countries by free channels or espionage; concentration on technology in education rather than the arts and social sciences; and giving scientists high places in Soviet society and rewards in position and higher living standards than the rest of their people also tend to give them a greater percentage of effectives than the United States develops.

However, there is one possibility for increasing the *effectiveness* of our existing active technical man power that has not been sufficiently emphasized by interested agencies. The experience of the author in this particular field recommends this idea for serious consideration by all concerned, since it will require a spontaneous and cooperative effort by those of us in industry to bring it about.

Edison, in explaining his incessant reading of scientific papers, patents, books, etc., said, "I start where the last man left off." He studied and collected information to avoid useless repetition of old experiments and to obtain ideas new to him. Yet, in spite of his example and that of the most highly productive scientists and engineers over the past 50 years, much of industry is today failing to make use of this obvious tool for tremendously increasing the effectiveness of technicians.

The tool that industry is failing to use as effectively as it might is the technical library. This is particularly true of the paper industry and that is difficult to understand since it has had a very highly organized and available literature for many years. This has been made possible through the unselfish effort and devotion of a relatively few people such as the late C. J. West and Edith Strohschneider, bibliographers, abstractors, and editors—unsurpassed in this field. Their compilations and abstracts are well known and are among the most useful tools for paper technologists. One must call attention to the workers of *Chemical Abstracts* and many others who contribute to collecting the literature of papermaking.

Nevertheless, we find very few pulp and paper mills with any appreciable library facilities and much of the technical personnel lack training or interest in using the material that could possibly be available. This may account to some extent for the unpalatable fact that such a large percentage of the inventions and developments applicable to pulp and paper are being made by firms which supply materials and equipment to the industry. Absence of literature facilities has in some cases also been used as a partial reason for lack of progress on the part of technicians in poorly equipped laboratories.

Over the past 15 years, the author of this paper has prepared literature surveys on various pulp and paper problems. The information learned and the ideas generated by consideration of such material, as well as the resulting high percentage of successful developments relative to the number undertaken, have convinced the author that adequate concentration on the literature available *will double the effectiveness of technical men* engaged in work other than that of a routine nature.

The body of literature and patents is the written record of a vast amount of technical effort and capital expenditure in an inexpensive form. By making it available to every technician in industry, it is possible to add a large increment of technical versatility and knowledge to our supply of technical man power. We cannot safely assume that the Russians will fail to make use of this essential tool. Therefore, if we do not, then in the future we shall be at an even worse disadvantage than comparative numbers of engineers being trained indicate.

As our technology expands, the chemical literature and patents are rapidly "mushrooming." Figure 1 is a reprint of statistics compiled by *Chemical Abstracts* (*2*) on the number of abstracts each year. In 1953, there were 61,273 abstracts of papers prepared and 11,906 summaries covered patents from various countries. Since these abstracts are primarily concerned with the field of chemistry, patent abstracts are only a small fraction of the total number of patents issued in the world each year. The data shown in Fig. 2 are compiled from several sources (*3*, *4*). The graph shows the United States patents issued each year from the beginning of the present system. The data for 1952 in Table II give the number of patents issued by various countries during that year. The total number of patents issued up to that time by each of the major countries is also given.

Obviously, it would be impossible for any individual technician in a mill to keep track of the original literature and patents if limited only to the field of papermaking and a complete library were available. For that reason it is necessary to depend upon abstracts and bibliographies of various sorts prepared by specialists who are full-time workers in that field. Various associations such as the American Chemical Society

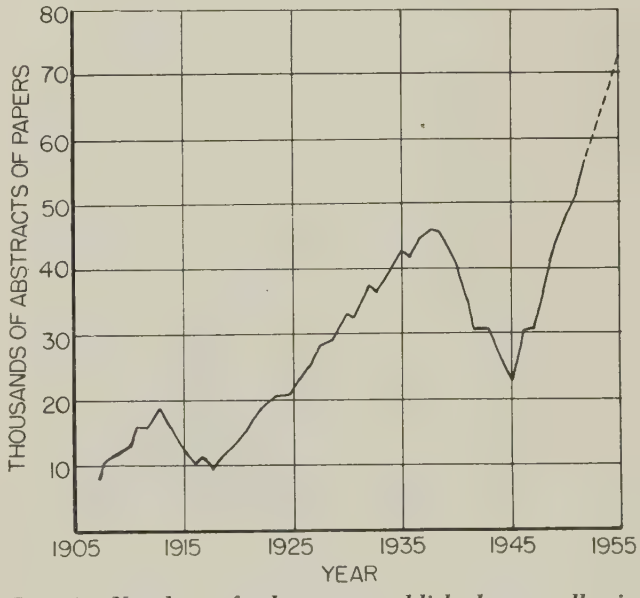

Fig. 1. Number of abstracts published annually in Chemical Abstracts. *Data:* Chem. Eng. News *(March 1, 1954)*

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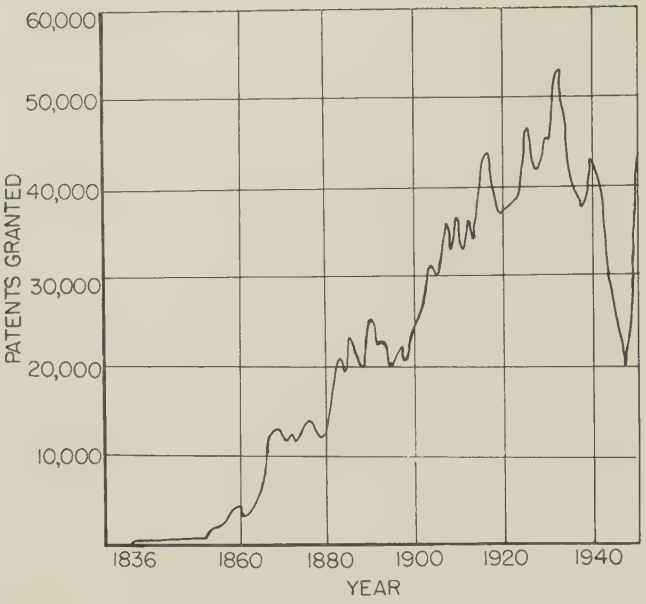

Fig. 2. United States patents issued each year since beginning of present patent system

and in our industry, TAPPI, have subsidized the centralized collecting of knowledge and abstracting so that the cost for those who utilize it is very low.

A recent symposium (*5–11*) covered the literature of cellulose and other materials related to the pulp and paper industry in a very complete and comprehensive fashion. From this information it can be seen that there is an overlapping and duplication of some abstract services although the few extensive and specialized abstract sources for the paper industry stand out remarkably when compared to others giving only a token, partial coverage.

No attempt shall be made to list anything other than the major sources of information generally available.

Bulletin of the Institute of Paper Chemistry, Library Notes (B.I.P.C.) is the most comprehensive abstract journal covering the literature and United States and Canadian patents on pulp and papermaking and related converting fields. It is available by subscription to nonmembers of The Institute of Paper Chemistry.

Covering all branches of pure and applied chemistry, *Chemical Abstracts* is by far the most extensive abstract journal and certainly the most useful in English-speaking countries. It contains a section on pulp and paper as well as other related fields.

TAPPI has published an extensive annual compilation, "Bibliography of Papermaking and U. S. Patents" with some collective issues but only the patents are abstracted. The "Quarterly List of U. S. Patents on Paper Making" is also compiled for this organization.

As for patents, *Official Gazette* of the U. S. Patent Office and the official patent journals of several other countries give either abstracts, lists, claims, abridgements, and/or illustrations of those granted. These items are generally not available outside specialized libraries and a reading knowledge of various foreign languages is necessary to make much of this material usable.

The abstractors and editors of these publications are doing an almost superhuman job in handling this growing mountain of information. No criticism of their superlative effort is intended or implied but some of the duplication and omissions in handling the literature should be pointed out and an effort made to correct them.

As one who uses abstract journals almost exclusively, the author finds only one additional thing to be desired in the *B.I.P.C.* If it were possible to include all the foreign patents

Table I. Technical Man Power—United States versus U.S.S.R.

	Year	*United States*	*U.S.S.R.*
Graduating scientists	1950	57,000	...
Graduating scientists	1954	29,000	...
Graduating engineers	1956	...	56,000[a]
Employed in technical fields	1940	...	2,500,000[b]
Employed in technical fields	1953	...	5,940,000[c]
Employed in technical fields	1954	5,000,000	...
Two year technical institutes	1954	1,000	3,700
Two year technical students	1954	50,000	1,600,000

[a] 5½-year course equivalent to training for a master's degree.
[b] 32% women.
[c] 50% women.

in papermaking and related fields then we could feel that in using *B.I.P.C.* nothing of current issue would be overlooked. However, due to difficulties of language and foreign patent publication and availability, this would be a project of considerable expense and magnitude if handled in the normal manner.

With regards to *Chemical Abstracts,* there is no question but that its general chemical coverage is all that could be wished for. However, for detailed and specialized phases of papermaking, particularly converting and the mechanical developments, much important material is of course not included. This is indicated by a check made of the patent index of *B.I.P.C.* against *C.A.* On an index page for United States patents chosen at random, there were listed in Volume 22 of *B.I.P.C.* approximately 168 patents but of these only a third could be located in the *C.A.* patent indices. The same *B.I.P.C.* volume listed 313 Canadian patents on papermaking whereas for the two years, 1951 and 1952, *C.A.* did not list any from that source. Of course *C.A.* lists many patents in the paper field, other than United States and Canadian, that are not included in *B.I.P.C.*

It is also obvious that there is considerable duplication of work in preparing abstracts of the same articles and patents for the *B.I.P.C.* and *C.A.* Some exchange arrangement should be made to eliminate this so that the effort could be expended on covering material not abstracted at present.

As for the TAPPI bibliographies and United States patent lists, there is no annotation of the former and duplication

Table II. Patents of Various Countries

Country	*1952 issues*	*Total through 1952*
United States	46,890	2,624,046
Germany	37,179	About 870,000
Germany	16,000[a]	
Great Britain	21,380	About 700,000
France	20,400	About 1,000,000
Japan	5,486	
Japan	10,411[a]	
Canada	9,700	
Italy	8,600	
Belgium	8,415	
Switzerland	8,008	
Spain	4,800	
Spain	3,428[a]	
Australia	5,248	
Sweden	4,611	
Austria	3,656	
Netherlands	2,207	
Union S. A.	2,141	
Denmark	1,665	
Norway	1,673	
Mexico	1,391	
Rest of Free World	7,061[b]	
Iron Curtain Countries	2,104[b]	
Total	232,454[b]	

[a] Design patents.
[b] Includes designs.

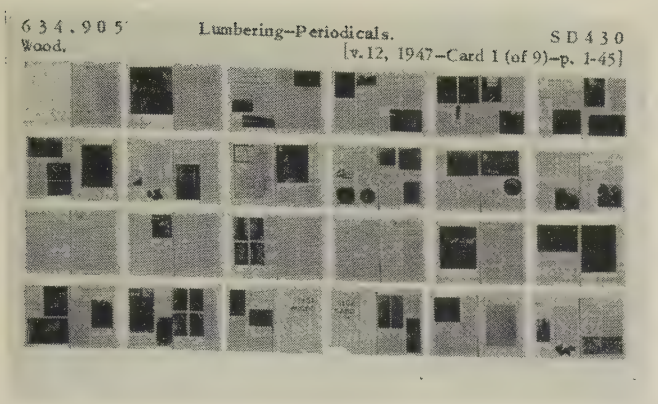

Fig. 3

exists in *B.I.P.C.* and *C.A.* However, there is no question but that these excellent compilations have formed the main body of references available to members of TAPPI for many years and undoubtedly they are currently of value to many technicians. It is the wish of this author, however, that the money spent for duplication of these services could be pooled to obtain complete coverage of foreign patents, for translations, and to abstract the tremendous accumulation of foreign patents and articles for many years back that form a considerable body of more or less hidden prior art in our industry. Another worth-while expenditure would be for a continuation of the preparation of annotated bibliographies on definite subjects in the field of papermaking similar to the ones prepared by the late C. J. West for The Institute of Paper Chemistry.

We should now consider certain aspects of these problems and possible solutions to them. The author is no expert in this field but attempts to collect literature and establish libraries with attendant difficulties have convinced him of the desirability of making the job of the "armchair" or library chemist more efficient and easier.

In the future, the cost of preparing abstracts and bibliographies will increase and additional personnel will have to be trained for and enlisted in this work. In the past, the unselfish efforts of C. J. West and others have made bibliographies of papermaking available to all at practically no cost. It is now time that the industry realizes it will have to pay more and more to have this continued. At that, such expenditure will be a small item for the results obtained.

As attempts are made to establish industrial libraries, it will be found that the supply of back issues of journals is limited and their costs plus the expense of binding and providing library space for them will become an appreciable item to people who do not recognize their value.

There is also the problem of persuading the abstract journals, magazine publishers, bibliographers, etc., to cooperate and follow some definite plans with regards to handling the literature of papermaking and thus prevent duplication while at the same time facilitating the work and extending the scope of present services.

In order to try to stimulate possibly interested groups in considering the literature problems, the author addresses this paper to the technical associations of the paper industry in various parts of the world as well as others who would be concerned. The objectives of a possible preliminary program can be outlined as follows:

1. A worldwide organization consisting of a member from each interested and contributing group could be set up with the chairmanship and operation of the committee under the guidance of TAPPI since that association has subsidized much of the bibliographic contributions to our industry.

2. Certain publication recommendations might possibly be sanctioned and brought to the attention of all publishers of journals in the paper field. Specifically, the following items are of great importance from the bibliographic standpoint.

a. All articles would have an abstract, in one or more of the principal world languages, which would be a concise digest of the article and not an elongated title.

b. To avoid unnecessary replication, journals would not accept technical articles which had already been published elsewhere, with the exception of translations and shortened versions of the "digest" type. If a verbatim translation were published, full acknowledgment would be made together with the original reference listed and by the author's permission. If a shortened version were to be published, this would be provided or approved by the author, and here, too, reference would be made to the original paper.

c. If the technical and scientific papers were printed in one section of the journal, with the pages consecutively numbered from issue to issue, then binding of the journals for reference purposes would be facilitated.

3. It would be very important to have the various technical associations of papermakers assume the responsibility for listing and abstracting in their official journals every patent in the field of papermaking and related subjects currently issued in their country. Translation of these abstracts could be allowed so that *Chemical Abstracts* or other journals could incorporate them into abstract journals of various languages. It might also be possible to subsidize some young engineers working in foreign patent offices to prepare bibliographies of past years' patents of the papermaking classes. Publication and translation of these into English might stimulate the worldwide circulation of journals published in other languages or some revenue might be derived from sale of translation and publication rights to some of the trade journals.

4. Publication of authorized translations of articles could be allowed for journals adhering to the literature convention. This would give foreign authors additional prestige and payment could probably be made for the translation. These could replace repetitious or marginal material now printed in many of the trade journals. Copies of translations not published could be deposited, by the individuals or companies who had them made, in the Library of Congress or John Crerar Library. A note on the existence of the translation

Fig. 4

Table III. Microcard Costs versus Binding Costs

Pages in book	Binding	Microcard cost per copy[a] 25 copies	100 copies	500 copies
500	$2.50	$2.50	$1.50	$1.25
1000	$3.50[b]	$5.00	$3.00	$2.25

[a] Viewers are approximately $155 and $255 (with page turning mechanism).
[b] The author was recently charged $5.00 for the binding of a 1000-page volume of *B.I.P.C.* and $6.50 for 2000 pages of *Chemical Abstracts*.

could be published in *Chemical Abstracts* and the translation made available through photocopy service.

5. To solve the problem of making inexpensive and complete libraries available to the paper mills, the committee could consider the various types of photographic reproduction. One such system is Microcards (*12, 13*) of which a sample and viewer are shown in Figs. 3 and 4. The Microcard Foundation has given an estimate of costs of Microcards of a journal as compared to the cost of binding a volume of the original publication. Table III gives these data. Microcards require the viewer but have the advantage over journals in that complete files of back issues would be available for less than the cost of binding and a large library could be maintained in a filing cabinet. As far as this investigator has been able to determine, the only journals which can be used as advantageously in the original as Microcards are the abstract journals, patent gazettes, and various indices. Once such a system as Microcards were chosen, it would then be necessary to obtain sufficient orders for sets of journals to have them reproduced. An agreement could be made with the publishers of each journal that Microcards would not be available until some time after publication of an issue, say a year or two, or only when current issues cannot be supplied by the publishers. A further interesting aspect of Microcards is their potential use as replacements for photoprint copies of individual articles as furnished by various libraries. In many cases the money charged for one photocopy print of an article would purchase a complete volume of the journal on Microcards, thus facilitating establishment of technical libraries at lowest expense.

6. The committee could foster various programs in the future for handling the literature and patents of our industry and continue to make them readily available in bibliographic form to correlate best with the major abstract journals; such as *Chemical Abstracts, B.I.P.C.*, etc.

The success of such a program will depend upon everyone who can possibly be interested in it. Your cooperation is invited.

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Presented at the 40th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 21–24, 1955.

Turbidity Number—A Measure of Pulp Additive Retention

J. S. HICKMAN

The paper manufacturer has always been extremely interested in new techniques which would enable him to exert a more careful control on the quality of his product. With the increased usage of additives by the industry, his problems concerning retention of these additives in the finished paper and undesirable build-up of them in white water have been increased many fold. Most of the techniques now in use are based upon analyses of the finished paper, either by chemical means or by physical testing of the paper. One of the chief drawbacks of these methods has been that they are time consuming and, hence, often provide no accurate knowledge of the extent to which the system is out of control until the tests are completed. Thus, he may produce large quantities of off-grade paper before corrections are made.

These same handicaps have also plagued the research man in his search for new and improved additives and methods of addition. It is the purpose of this paper to describe a new analytical technique based upon an optical examination of the tray or white water which shows promise as a new tool both for the production man and for the research chemist.

Optical techniques have long been recognized methods of chemical analysis. Methods based on colorimetry are standard in the quantitative determination of many materials. In more recent years the techniques of turbidimetry and nephelometry have been developed to use the reflected or scattered light given off by dispersions to measure the amount of dispersed materials present. The complex nature of dispersions has limited the accuracy of such techniques in comparison with analysis of solution systems by other optical methods; however, results within 1 to 2% error are attainable.

A typical system to which this method of analysis appears to be applicable is one in which the solid or dispersed phase is represented by the particles of an elastomeric latex such as Neoprene Latex Type 735. Scattered light values obtained when turbidity measurements are made on various concentrations of the neoprene dispersion are shown in Fig. 1. The various concentrations measured were obtained by dilution of the latex with permutit water.

A Fisher clinical electrophotometer was used for the turbidity measurements in these experiments. It determines the current required to match two beams of light of different intensity striking two photoelectric cells. Both light beams originate from the same source. One passes through a standard liquid, in this case water; the other passes through the liquid to be tested. Materials in the test liquid such as dispersed solids reduce the intensity of the transient light by absorbing and reflecting it. The scattered light index shown as the ordinate in Fig. 1 is actually a measure of the light not transmitted and includes not only the light scattered but also the light absorbed.

The first laboratory problem undertaken with this technique was concerned with a study of any improvement in the stability of Neoprene Latex Type 735 when added to pulp slurries furnished with white water. Destabilization of the colloidal system by the salts in the water would be accompanied by deposition. As a result an analysis of the solids content of the water phase of such pulp slurries by the turbidity technique would indicate the amount of colloid still present and give an indication of the degree of stability. The more colloid remaining in dispersion, the greater the stability of the latex in the pulp system.

The laboratory technique is rapid and simple. Five grams of air dry pulp are slurried in water containing various

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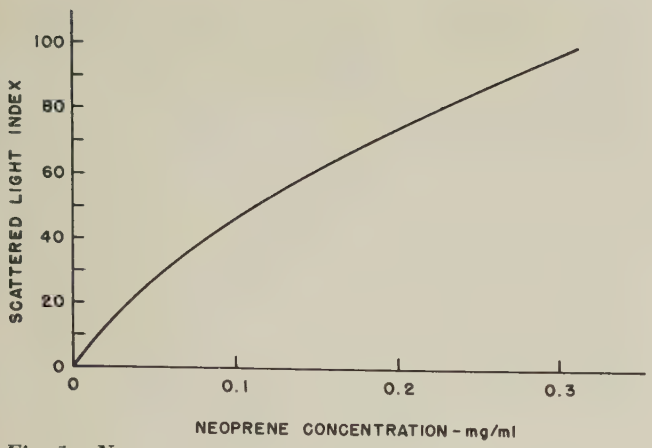

Fig. 1. Neoprene concentration versus index of scattered light

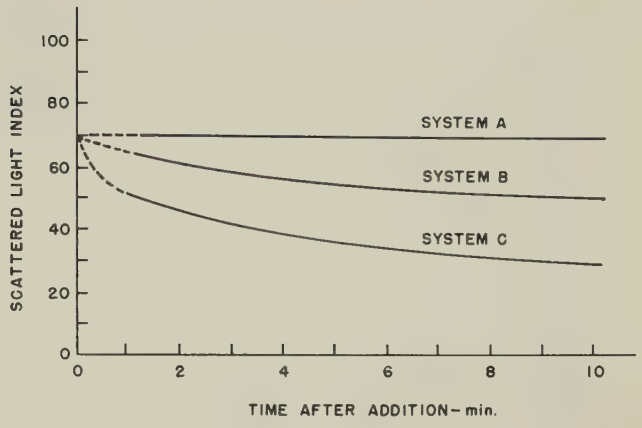

Fig. 3. Effect of dispersing system on colloidal stability (sulphate ion = 400 p.p.m.)

amounts of sodium sulphate (simulated white water) at a consistency of 0.35%. The slurry is kept under gentle agitation in a beaker and after the pulp is well mixed, a 5% dispersion of the latex is added to the slurry to give 5 parts of elastomer per 100 parts of pulp. This corresponds to 0.18 mg. of elastomer per ml. of water.

Samples are taken at various time intervals after the addition of the latex. Each sample is immediately filtered through a porous wool mat to remove the pulp fibers. The filtered water containing any uncoagulated neoprene is immediately placed in the photometer and the scattered light value determined.

The results obtained are shown graphically in Fig. 2. Increasing amounts of sulphate ion result in a loss of neoprene in the water phase and this destabilization effect is shown by a lower value for the scattered light index.

Most of the destabilization occurs very rapidly; however, coagulation at a slower rate occurs for relatively long periods of time. Although the initial rapid destabilization is of principal concern, it is impractical to measure. The extension of the curve to longer periods of time permits interpolation of the initial severity of destabilization and is thus worth while.

Having established that this turbidity technique was capable of giving a quantitative measure of the stability of a colloidal system under various water conditions, the next obvious step was to apply it to a study of the effect of varying the stabilizing and dispersing agents used in the colloidal system. Many different methods of stabilizing a latex system are available to the chemist. Three of those which are known to have different degrees of stabilizing activity were selected for study. It is outside of the scope of this paper to describe in detail the chemicals used and they are merely identified as dispersing systems A, B, and C. Using the technique described above, each of these stabilized latices was added to pulp in which the water phase contained 400 p.p.m. sulphate ion. The tendency of the latices to coagulate was determined by the turbidity technique and the results obtained are shown graphically in Fig. 3. It will be readily apparent that system A stabilized the latex far better than the other two systems and furthermore by comparison with Fig. 2, it will be seen that this system is as good in water containing 400 p.p.m. sulphate ion as the control system was in the permutit water which contained no sulphate ion.

The same three systems were next tested in water containing 1200 p.p.m. sulphate ion. The results obtained are shown in Fig. 4. These results are essentially identical with those obtained at the lower concentration of sulphate ion.

The ultimate test of the practicability of any analytical procedure is its value in developing a better product. By using another test on the finished paper, it was possible to verify the improved stability of system A in high sulphate ion content water. It has been established by previous investigators (*1*, *2*) that the wet-strength efficiency of neoprene requires that the latex system be stable when added to the pulp slurry until it can be coagulated under certain favorable conditions. Figure 5 compares the wet strength developed with the three systems that were studied at various levels of sulphate ion concentration.

The data presented in Fig. 5 show that using stabilizing system A the wet strength of the paper produced is essentially independent of the sulphate ion concentration of the make-up water. Furthermore, by comparison with Figs. 3 and 4, it will be seen that the relationship between the wet strength of the paper and the sulphate ion concentration for each of the stabilizing systems A, B, and C is essentially the same as that established in the preliminary analysis for

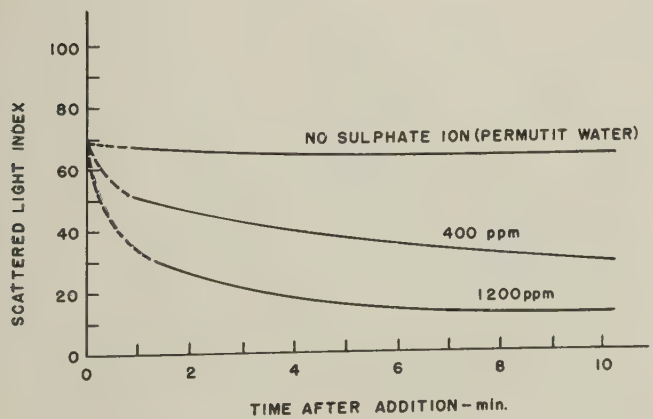

Fig. 2. Effect of sulphate ion concentration on colloidal stability

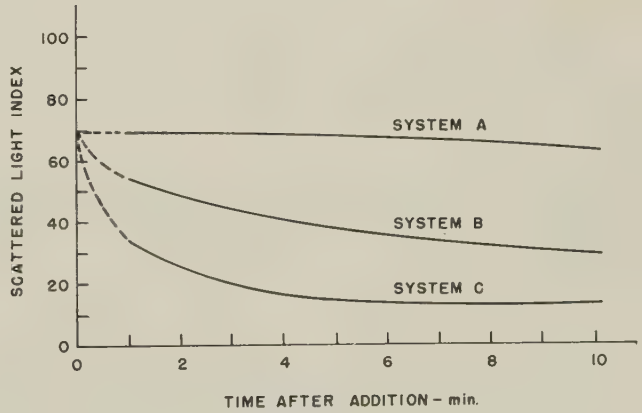

Fig. 4. Effect of dispersing system on colloidal stability (sulphate ion = 1200 p.p.m.)

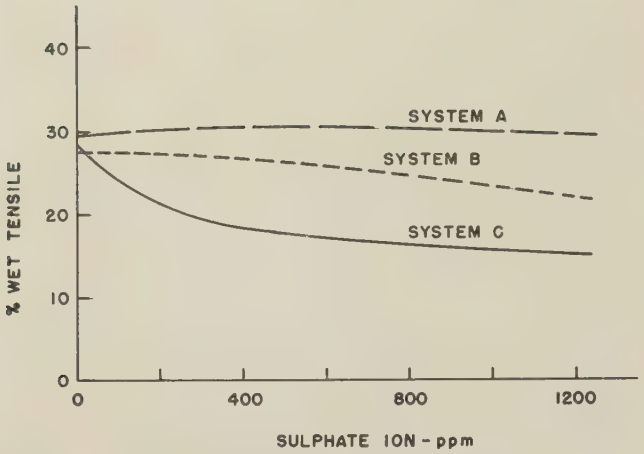

Fig. 5. Sulphate ion concentration versus per cent wet tensile

the relationship of the scattered light index and the sulphate ion concentration.

The turbidity number technique has thus assisted in the development of a latex stabilizing system which gives adequate protection to the colloid in all high ion content waters. A latex, specifically Neoprene Latex Type 736, incorporating the stabilizing system developed, which is suitable for addition to any mill furnish water, has subsequently been placed on the market.

More recently the turbidity number technique has been used to study other factors affecting the efficiency and retention of colloidal particles when added to pulp slurries. As an example Fig. 6 illustrates the effect of pulp freeness on the retention of neoprene. It has long been know that some hydration is necessary to insure adequate retention of neoprene particles. The turbidity number technique established quickly that a freeness of 720 ml. Canadian represents the degree of hydration necessary for a 5% neoprene addition when Ostrand no. 60 pulp is used. At freenesses above this point, the fiber area avilable is insufficient for complete deposition of the colloid. With the turbidity technique, this work required only about 3 hr. of a technician's time apart from the time necessary for beating. Regular techniques for the same set of experiments would have required at least 12 hr. apart from the beating time plus another 6 hr. for chemical analysis. In this set of turbidity number tests the same technique was followed as previously described except that a predetermined amount of 1% alum was added to give a pH of 4.5.

Other laboratory work on different problems with the turbidity number technique has proved equally successful. Use of the technique on a mill scale has not been extensive enough to include data in this paper. Slightly different techniques from those so far described would be required on a mill scale. The initial step would be to establish scattered light curves for machine tray water under normal satisfactory operating conditions. Comparisons with the tray water during any future runs could then be made and conclusions as to the efficiency and retention of the additive or filler made. Another approach would be to study the build-up of filler in the water system. Under a given set of conditions in a closed water system the amount of filler in the paper and in the water is in equilibrium. After several hours running on a particular grade, equilibrium should be reached and no further change in the turbidity of the tray water would be expected to occur. Once the data on such an equilibrium are developed, the tray water on subsequent runs on the grade under question could be analyzed optically to determine if a similar equilibrium is being approached and, if so, how rapidly.

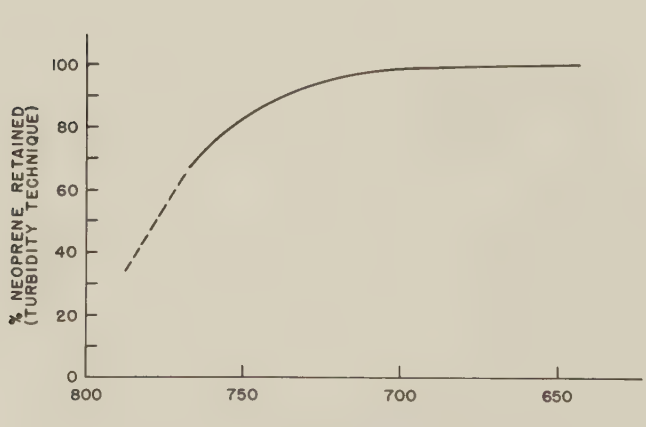

Fig. 6. Per cent neoprene retained versus fiber area

In summary, the optical technique of studying the filtrate water of pulp slurries has proven a good laboratory method for studying the retention and efficiency of pulp additives. Advantages of the technique are twofold. It is inexpensive and rapid and can screen out many of the possible variables to be studied in a large research program. It has the further advantage of permitting decisions to be made while the experiment is in progress without waiting for extensive chemical or physical property tests. Preliminary work has indicated that the technique will also be of value on a mill scale and that its use as a routine control test both in the laboratory and the mill can save the papermaker time and money.

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The Use of Reactive Titania for Crosslinking Cellulose Fibers and for Fixation of Inorganic Fillers to Cellulose

PAUL LAGALLY

In inorganic analytical chemistry, it is well established that metal hydroxides can be prevented from polymerizing and precipitating if certain organic compounds are added which contain several OH and NH_2 groups. This technique (called masking, according to Feigl (*1*)) has been used to produce a stable monomer or low polymer of orthotitanic acid. The fact that the Ti^{4+} ion has a coordination number of six with respect to the oxygen and an excess charge of only four causes $Ti(OH)_4$ to polymerize and precipitate.

On the basis of Weyl's concept of the screening requirements of highly charged cations (*2*), diluted aqueous solutions were produced which contained chemically active $Ti(OH)_4$ in combination with organic molecules such as methylglucoside or urea. These solutions, which were stable for days, precipitated $Ti(OH)_4$ derivatives on cellulose, thus crosslinking the fibers and increasing the wet strength. The nature and the concentration of the compounds which were used for the "temporary screening" of the titanium ion made it possible to control the rate of the copolymerization of the $Ti(OH)_4$ with cellulose, and other organic (starch) and inorganic (clay) substances which contain hydroxy groups.

Paul Lagally, Research Chemist, Linden Laboratories, Inc., State College, Pa.

In principle, any combination of a water-soluble orthotitanate with a suitable screener can be used to delay hydrolysis of the titanate and to produce a highly reactive form of monomer or low polymer orthotitanic acid. Solutions of this type allow copolymerization of the orthotitanic acid to take place at a reasonable rate but suppress the polymerization of $Ti(OH)_4$ which leads to precipitation.

The orthotitanic acid was prepared from organic titanium compounds which are water soluble and which hydrolyze only slowly. Chelated esters such as triethanolaminetitanate or N,N,N′,N′ - tetrakis(2 - hydroxypropyl)ethylenediaminetitanate were used.

Example 1: 284.0 grams of isopropylorthotitanate (1 mole) were mixed with 298.4 grams of triethanolamine (2 moles); 0.120 grams of this mixture were dissolved in 300 ml. water, and 100 ml. of a 50% solution of methylglucoside was added. In order to neutralize this mixture, 20 ml. conc. HCl was added. Diluting with water to 600 ml. did not produce hydrolysis. This solution was particularly well suited for cross-linking cellulose fibers because it contained the Ti(OH) in a reactive form.

For the purpose of attracting and fixing fillers to cellulose it was found that urea was more advantageous for producing highly reactive titanic acid.

Example 2: 120 grams of a mixture of 1 mole isopropylorthotitanate and 2 moles triethanolamine were dissolved in 200 ml. water, and 200 ml. of a 50% solution of urea was added. The resulting mixture was neutralized with 25 ml. conc. HCl and diluted with water to 600 ml. Consequently 100 ml. of this solution contained 3.980 grams $Ti(OH)_4$, which is equivalent to 2.744 grams TiO_2.

Clay and calcium carbonate were attracted and fixed to cellulose as follows: 250 ml. 2% cellulose pulp (60% soda, 25% sulphite, 15% old paper) was mixed with 15 ml. of a 10% dispersion of filler in water. Then to successive similar portions of this stock mixture, 2, 1, 0.5, and 0.1-ml. portions of the above-described solution of titanic acid were added after diluting with 100 ml. water, and the whole mixture well stirred. After 5 min. reaction time another 550 ml. water was added with stirring and sheets were formed from the resulting stock which now contained 0.55% cellulose.

Analytical data obtained from these sheets reveal that the retention of fillers by cellulose is improved by small amounts of titanic acid. Titanic acid in amounts of 1% and less, added to the pulp increased the filler content of the paper from 6% up to 19%. Theoretically, complete attraction and retention would produce 23% filler content.

The importance of fixing filler particles to the surface of the fibers has been emphasized previously (*3*). Incorporation of fillers into the sheet by mere filtration lowers the strength of the paper and causes the so-called "two-sidedness"—presence of more filler on the one side of a sheet than on the other—because filler retention ordinarily mainly consists of a filtration mechanism.

It is the purpose of the experiments described to attract and hold fillers more uniformly to the surface of the fibers and thereby to distribute them more uniformly throughout the sheet by the use of titanic acid. A more extensive description of this process with respect to both theory and practical applications will be presented later.

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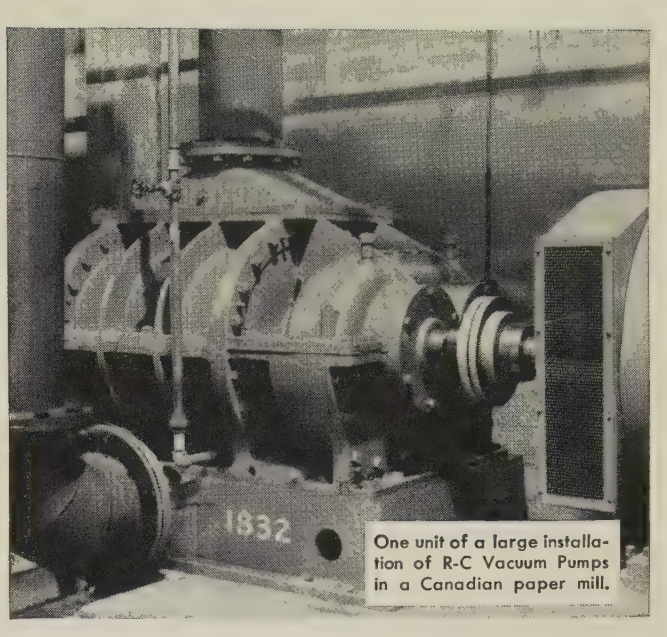

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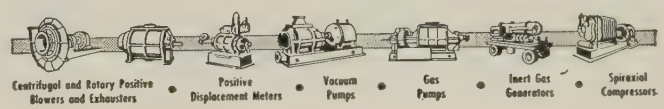
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Calendar of TAPPI Meetings

NATIONAL MEETINGS

Fourth Statistics Summer Course, Forest Products Laboratory, Madison, Wis., July 10–23, 1955.

Fifth Fundamental Research Conference, Institute of Paper Chemistry, Appleton, Wis., September 15–17, 1955.

Second Mechanical Pulping Conference, Poland Spring House, Poland Spring, Me., September 19–21, 1955.

Fifth Testing Conference, Hotel Sheraton-Kimball, Springfield, Mass., September 28–30, 1955.

Fifth Corrugated Containers Conference, Morrison Hotel, Chicago, Ill., October 5–7, 1955.

Twelfth Agricultural Fibers Conference, Alton, Ill., October 13–14, 1955.

Ninth Alkaline Pulping Conference, Hotel Patten, Chattanooga, Tenn., October 19–21, 1955.

Tenth Engineering Conference, Rice Hotel, Houston, Texas, November 7–9, 1955.

Tenth Plastics-Paper Conference, Brooklyn Law School, Brooklyn, N. Y., November 14–15, 1955.

Forty-First Annual Meeting, Commodore Hotel, New York, N. Y., February 20–23, 1956.

Seventh Coating Conference, Benjamin Franklin Hotel, Philadelphia, Pa., May 7–9, 1956.

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